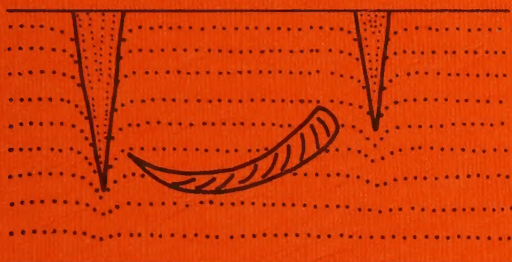




UNIVERSITY OF LUND
DEPARTMENT OF
QUATERNARY GEOLOGY

Thesis 4



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Microfossils and their stratigra-
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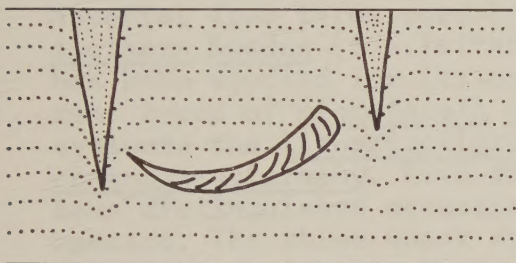
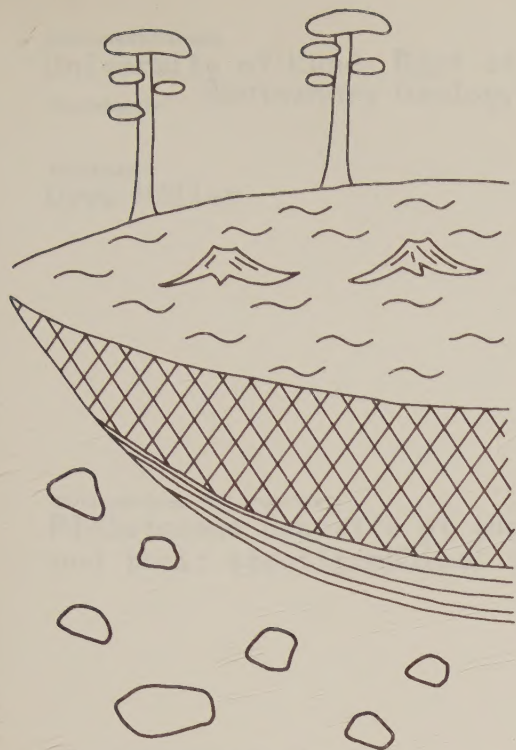
PLEISTOCENE DEPOSITS OF THE ALNARP VALLEY, SOUTHERN SWEDEN -
MICROFOSSILS AND THEIR STRATIGRAPHICAL APPLICATION

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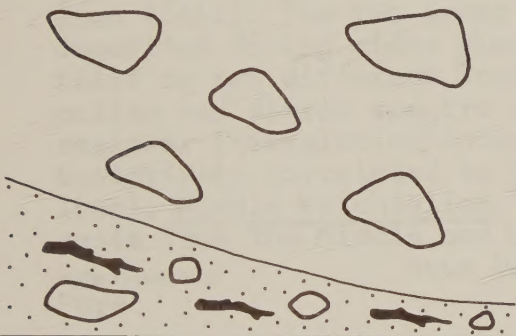
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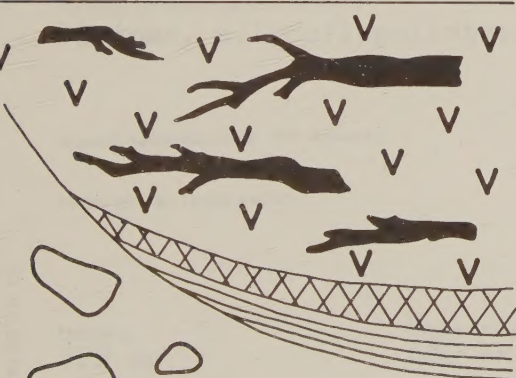


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PLEISTOCENE DEPOSITS OF THE ALNARP VALLEY,
SOUTHERN SWEDEN - MICROFOSSILS AND THEIR
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Pleistocene deposits of the Alnarp Valley, southern Sweden - Microfossils and their stratigraphical application

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Material from three core-borings in the Alnarp Valley, southern Sweden (the Tofthög-, Hyby- and Gärdslov-cores) has been studied for its content of microfossils. Different types of microfossil analysis have been applied to evaluate the lithostratigraphy, biostratigraphy and chronostratigraphy. Five different types of till have been distinguished according to their microfossil content spectra. The three upper till beds are proposed as being deposited during the last glaciation (Late Middle Weichselian tills). The two lower till beds are assumed to be deposited during older glaciations (Saalian and Elsterian tills or two different Saalian tills). The Pleistocene pollen and diatom spectra in the fine-grained sediments register interglacial/interstadial stages/substages tentatively correlated to Holsteinian (or Middle Saalian), Middle Weichselian, and Late Weichselian. Sediments from the Middle and Late Weichselian substages have been radiocarbon dated.

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PREFACE

The present paper is a result of a prolonged investigation, carried out during the period 1965 - 1977, interrupted several times by other tasks. These circumstances have had a negative effect upon the entirety of the present study. The main part of the material was prepared for analysis at the initial stage of the investigation. In recent years more effective preparation methods have been developed, which could have shortened considerably the time-consuming analytical work and also produced results more statistically valid. I hope to have the opportunity in future investigations, concerning Pleistocene stratigraphy, to apply modern effective preparation methods and more advanced analysis techniques (fluorescence and electron microscopy, computer programming and absolute frequency calculations). In the meantime the present study will serve as an introduction to the methods used and their stratigraphical application.

The initiator of the present investigation was the late Dr Phil Fritz Brotzen, the previous head of the Department for Research and Applied Geology, Geological

Survey of Sweden (SGU). The memory of his never-failing enthusiasm and encouraging attitude towards this work has been the spur, which has persistantly helped me to persevere with this study.

I wish to thank Professor Björn E. Berglund, Department of Quaternary Geology, University of Lund, for his valuable support and positive criticism concerning the continuation, supplementary research and final stage of the present investigation.

I wish to express my gratitude to the previous and to the present Directors General, SGU, respectively Mr Karl Albert Lindbergson and Mr Gunnar Ekevärn, who have been well-disposed towards the present work.

Due to deep understanding shown by the present head of the Department of Quaternary Geology and Hydrogeology, SGU, Dr Jan Lundqvist and by my chief Dr Erik Fromm, my colleagues and the staff at the Micropaleontological laboratory, SGU, I have obtained the opportunity to conclude the investigation.

I am very grateful to Dr Kaj Nilsson for the period of collaboration at SGU, during which he introduced me to the problems of Pleistocene geology in Scania. Extensive discussions with him concerning stratigraphical problems in the Alnarp Valley and his great interest in the present study have been a valuable stimulant.

For inspirational discussions and valuable advice I wish to thank Dr Svend Th. Andersen, Geological Survey of Denmark, Professor Alexis Dreimanis, Geological Department, University of Ontario, Canada, Professor Carl-Gösta Wenner, Department of Quaternary Geology, University of Stockholm, and Dr Risto Tynni, Geological Survey of Finland.

Discussions with the research colleagues at the Department of Quaternary Geology, University of Lund, Lena Adrielsson, Olof Andersson and Erik Lagerlund have provided new impulses and information of current interest.

Advice and generous information obtained from my colleagues at SGU, Dr Göran Kjellström and Dr Erik Norling, concerning microfossils and Scanian pre-Quaternary stratigraphy, have been of invaluable help.

The staff of assistant workers has been numerous. I am much indebted to all of them and wish to express my gratitude to the members of the present and previous staff of the Micropaleontological laboratory, SGU. Ann-Marie Robertsson, F.L. has helped with valuable assistance and advice on the present work and critically read this manuscript. Georgia Olsson, Elfriede Gabriel, Inger Österman, Irma Ortman, Berit Henriksson-Ottosson, Agneta Karlén-Lundh, Raija Sethi and Basia Horn have aided with preparative and analytical assistance. The late Bengt Falkenström gave analytical and photographic assistance concerning siliceous microfossils. Antoni Perlowski translated Russian literature of special interest for the present study.

Stina Ekman, Soil laboratory, SGU, carried out the determinations of loss on ignition. Kurt Johansson, Chemical Department, SGU, determined the organic and graphitic carbon content. Claes Ålinder, Chemical Department, assisted with the scanning electron microscope.

Lars Engstrand and Sandor Vazcy, Laboratory for radioactive isotope geology, the Museum of Natural History, Stockholm, have helped with the radio-carbon datings and Uno Samuelsson with the photographic work.

My deepest gratitude is conveyed to Greta Hellström for the skilful drawings. With the assistance of Ulla Skarin and Inga Palmaer she contributed to the illustrative part of the present paper. I also wish to thank them for their tolerance and never-failing support.

I am much indebted to Dr Dorothy Guy-Ohlson, who has helped me with the linguistic examination of the present text and given valuable advice concerning palynomorphs, and to Jill Blomstrand for typing the manuscript for offset printing.

Last but not least, I wish to express my sincerest thanks to my whole family for the best imaginable support and understanding in connection with this work.

Danderyd in April 1977

Urve Miller

1. INTRODUCTORY CHAPTER

1.1. Introduction

The Alnarp Valley in south-western Scania, with its impressive Quaternary deposits, built up by alternating strata of till beds and sediments, is an important ground-water reservoir (aquifer) for the densely populated most southerly part of Sweden. The age of the typical Alnarp sediments and the stratigraphy of the till beds has been, since the Swedish geologist N.O. Holst published in 1911 his sensational Alnarp River theory (Holst 1911), a subject of great current interest in Swedish Quaternary geology.

In connection with an investigation about the water supply in south-western Sweden (Scania and Halland), the Geological Survey of Sweden (SGU) drilled an exploratory core in the south-western part of the Alnarp Valley (K. Nilsson 1971). The boring was made in 1964 at the farm Tofthög, near Skivarp. In the following years (1965-66) two more such core-borings were carried out in the Alnarp Valley, at Hyby and at Gärdslov (Fig 1). These borings were defrayed with the funds granted by the Swedish Natural Science Research Council (NFR) to the late Dr Phil Fritz Brotzen.

The first stage of the research work was carried out in the years 1964-67, in co-operation with Dr Kaj Nilsson, who conducted the borings and was in charge of the lithostratigraphical and glacial geological investigations.

During the period 1968-73 (because of precedence given to other tasks) the research work on the Alnarp material, was almost abandoned at SGU. The analyses made during these years have been carried out mainly as sporadic home-work. The present investigation could be continued due to an encouraging grant from the NFR in 1973/74 and the interest shown by Prof Björn E. Berglund, head of the Department of Quaternary Geology, University of Lund, who, in these years actualized in his department intensified research upon Pleistocene stratigraphy in Scania.

The main aim of the present study has been to test and determine whether the reworked microfossils in minerogenous deposits may be lithostratigraphically applicable, as a complement to fine gravel analysis, i.e. determination of rock fragments, grain size 2-6 mm, in soil samples (Lundqvist 1952). Soils

composed by finer fractions (grain size < 2 mm): sand, silt and clay are not determinable by the fine gravel analysis. For instance the content of unconsolidated, fine-grained Tertiary and Upper Cretaceous material will not be represented at all. Also other easily disintergrated types of fine-grained sedimentary bedrock may disappear from the fine gravel composition and are traceable only more or less locally in conjunction with the proximate bedrock. In boulder clay and clayey till fine fractions make up $3/4$ or more of the composition. Also in this case the fine gravel analysis is difficult to accomplish.



Fig 1. The general location maps. The Alnarps Valley, Scania, southern Sweden and its extension to the north-west and south-east.

The size of microfossils analysed in the present study mainly corresponds to the grain size silt (0.002 - 0.06 mm) and fine sand (0.2 - 0.06 mm). Mesozoic and Tertiary rocks and sediments contain characteristic types of pollen, spores, dinoflagellates and siliceous microfossils (diatoms, silicoflagellates, sponge spicules etc). Reworked in Quaternary deposits they may inform of the origin of the fine fractions in tills and sediments and thus contribute to the knowledge of different till types and ice movements in south-western Scania.

The second purpose of the investigation has been to elucidate the biostratigraphic value of the Quaternary microfossils in the minerogenous sediments of the Alnarp Valley, concerning not only the typical Alnarp sediments, but also the other intermorainic fine-grained sediment layers. The examination of these sediments in order to find out if they contain pollen- and/or diatom spectra which can indicate interglacial or interstadial conditions may contribute to the chronostratigraphic division of the Pleistocene deposits in the Alnarp Valley. This might also settle the questions whether or not the so-called Alnarp sediments are of the same age, independent of their sometimes different stratigraphical position and sediment type (lacustrine and fluvial).

1.2. A brief outline of the geology of southern Scania and the Alnarp Valley

1.2.1. The bedrock

Scania, the southernmost part of Sweden, is characterized by a very complex geology (Fig 2). The bedrock is composed of Precambrian as well as sedimentary rocks of different age and diagonally (north-west to south-east) crossed by a tectonic disturbance line (the Tornquist line), between the Fennoscandian Border Zone and the Danish Embayment (Fig 3, according to Bergström in Bergström et al 1973).

The Precambrian bedrock (Fig 2) occurs in the horsts Romeleåsen and Linderödåsen, ridges extending parallelly to the Fennoscandian Border Zone, in north-western to south-eastern direction through southern Scania.

Paleozoic bedrock is represented by Cambrian sandstone in the north-eastern part of the area, immediate to the Precambrian bedrock, by Cambro-Silurian shales in a belt between the ridges, extending in the same north-western to south-eastern direction.

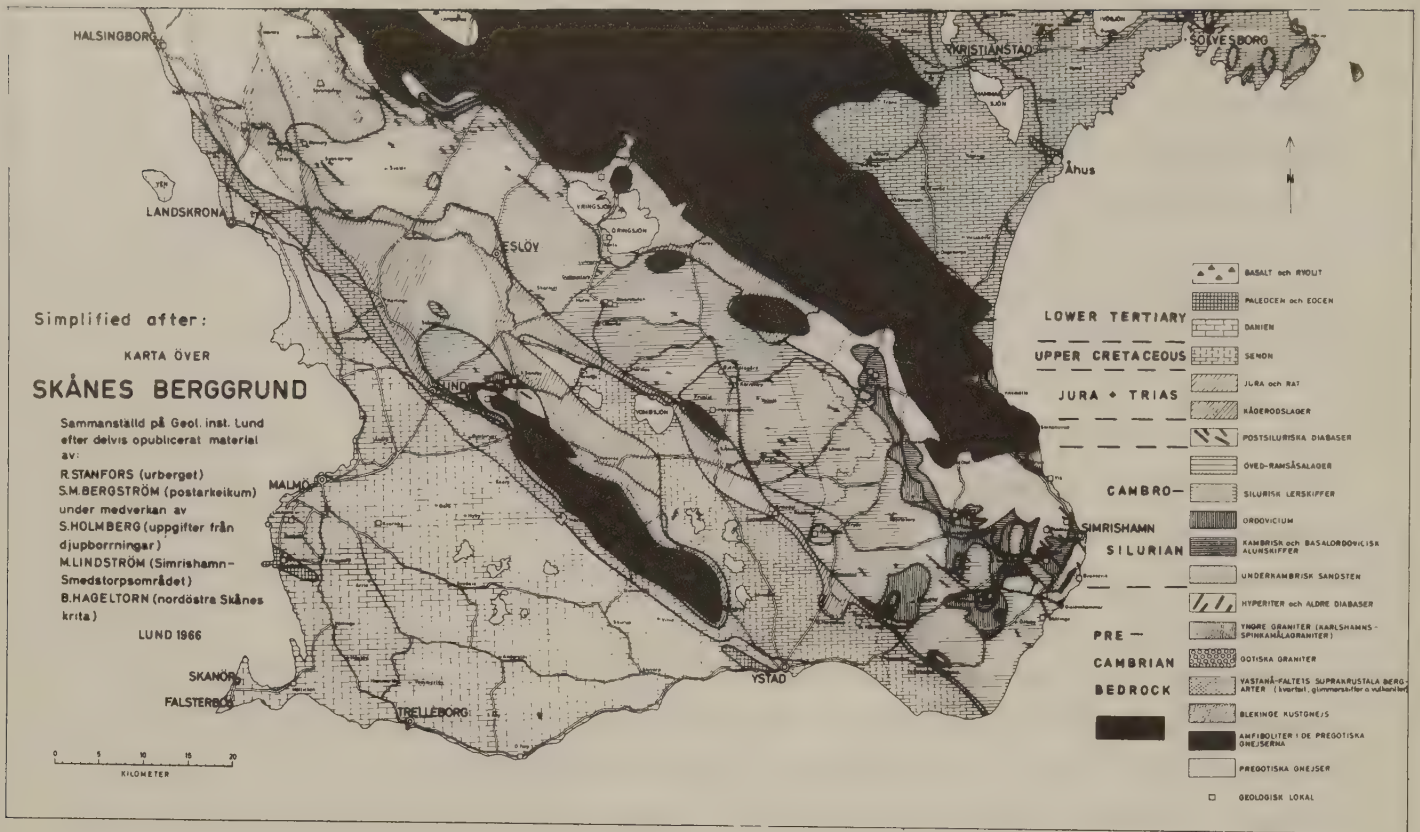
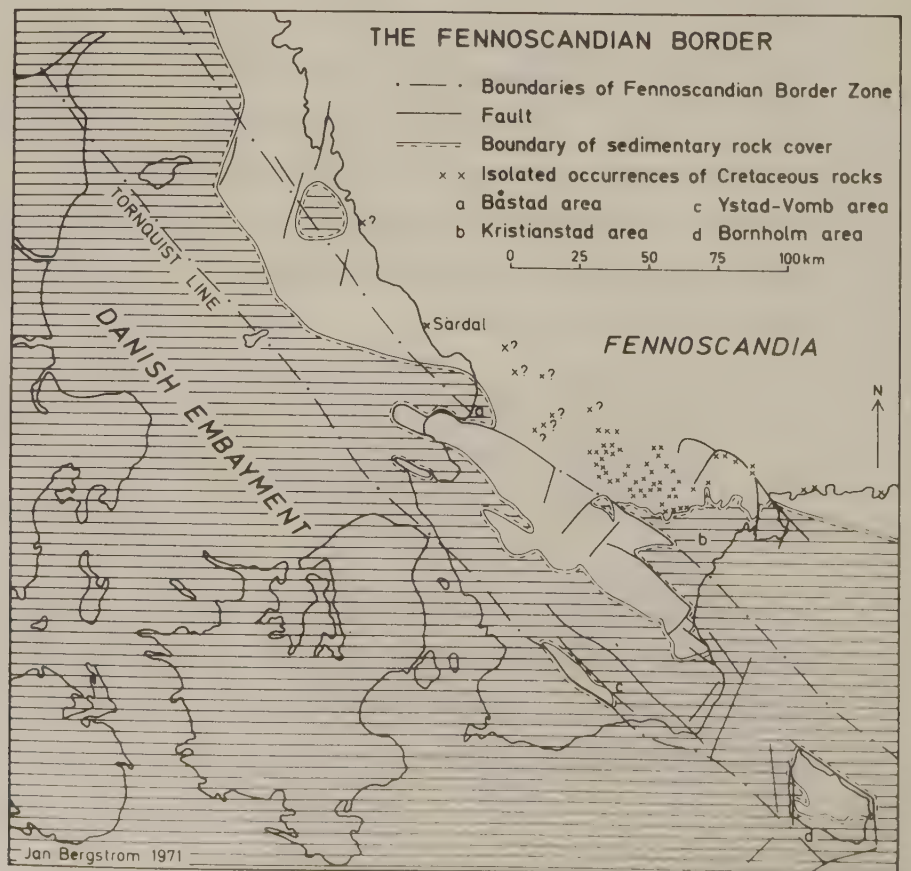


Fig 2. The bedrock of southern Scania (simplified after the bedrock map of Scania, Stanfors et al 1966).

Fig 3. The boundary between the Fennoscandian Shield and the Danish Embayment. (after Bergström et al 1973, Fig 1).



Older Mesozoic bedrock (Jurassic and Triassic) occurs mainly in the western part of Scania, but continues as narrow strings in south-eastern direction.

In south-western Scania the bedrock for the main part is composed by Upper Cretaceous, Senonian sandstone and marl (Cenomanien - Campanien) chalk (Maast-richtien) and Lower Tertiary limestone (Danian, Lower Paleocene). Small areas with Lower Tertiary (Paleocene - Eocene) deposits occur south of Malmö and at Ystad. Loose boulders (erratic blocks) of Tertiary bedrock (Upper Paleocene) are known from the Ystad district and at Maglehem. At Åhus, clay of supposed Tertiary (Eocene) age occurs. Dated on account of the rich content of marine diatoms, silicoflagellates and amber (Cleve-Euler & Hessland 1948). Later investigations have shown that the clay probably is glacial, and at least in its upper part consisting of boulder clay (K. Nilsson 1966), with extremely high content of reworked material of Lower Tertiary (Eocene) age (Miller in K. Nilsson 1966). Marine Lower Eocene deposits, rich in siliceous microfossils occur in Denmark, north-western Jutland, in the Limfjord-district (moler-formation). Senonian deposits, containing marine diatoms and silicoflagellates are known from the Gulf of Gdansk (Schulz 1935).

1.2.2. The Alnarp Valley

In the limestone bedrock (Danian) of south-western Scania, there is a valley (graben) extending from the coast of the Baltic Sea, west of Ystad to north-west, past Malmö and Landskrona, to the Öresund Strait. It continues below the Öresund to the north-eastern part of Sjaelland and farther to north-west in northern Jutland. In the opposite direction towards south-east, the valley continues below the Baltic Sea to Poland (Gulf of Gdansk) and farther to south-east (Fig 1).

The medium width of the valley is about 5 km. The valley bottom lies approximately 60 m below present sea-level. Topographically the valley is not observable because it is filled by Quaternary deposits (Fig 4).

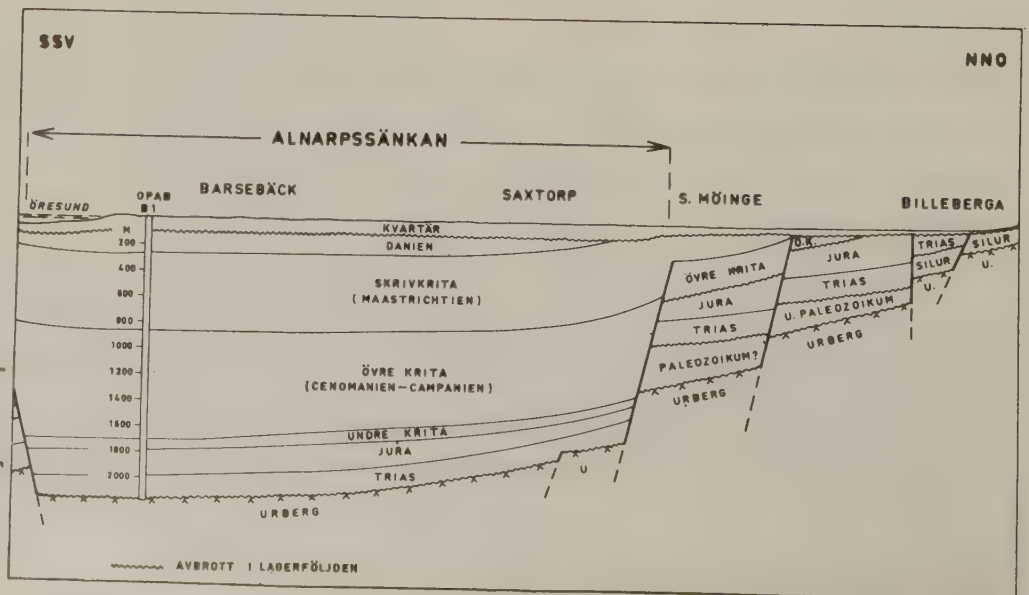
In the publication "Alnarpsdalen" N.O. Holst presented the opinion that the valley was eroded by a large pre-glacial river, the so-called Cromer-river, a continuation to the river Weichsel (Vistula or Visla), which ran through south-western Scania, north-eastern Sjaelland, to northern Jutland and discharged its waters into the Norwegian Furrow (Holst 1911). Holst considered the sedi-

Fig 4. View from the northern part of the Alnarp Valley. The hummocky landscape with the horst Romeleåsen in the background. (Photo B. Ringberg - 77).



ments in the valley be of fluvial origin, covered with till beds deposited during the last glaciation. The present opinion is that the valley originally was formed by tectonic movements as a graben (Brotzen 1938, Sorgenfrei 1945), but during interglacial and/or interstadial periods it contained a river that drained at least the southern part of the Baltic, including rivers like Vistula and others (K. Nilsson 1973). According to Norling in the "Description of the Quaternary map Malmö NV" (Norling in Ringberg 1976) the tectonic disturbance line (the Tornquist line) between the Fennoscandian Border Zone and the Danish Embayment, runs parallelly to the Alnarp Valley, near to its northern side (cf Fig 3). The Valley seems to have been formed in the oldest part of the Mesozoic or in the youngest part of the Paleozoic and has thereafter successively been pressed downwards by the sedimentary deposits of Mesozoic and Lower Tertiary age (Fig 5, after Norling in Ringberg 1976).

Fig 5. The Alnarp Graben (Alnarp Valley). SSW-NNE oriented cross section showing the post-Archaeon stratal sequence of the map area Malmö NV. (After Norling in Ringberg 1976, Fig 3).



1.2.3. The Quaternary (Pleistocene) deposits of the Alnarp Valley

The Alnarp sediments can have a thickness of more than 50 m and contain sporadically macrofossils of plants and animals (identified by Holst 1911). The lower gravelly parts are often rich in amber. The main part of the macrofossils and the amber are supposed to be of Tertiary age, transported to the valley from the south-east. Among the plant fossils are also noted representatives for Quaternary arctic and temperate floras (Holst 1911).

In connection with well-borings a till bed was sometimes found underlying the Alnarp sediments. Thus the age of the Alnarp sediments was limited within the Quaternary period.

The Quaternary stratigraphy in the north-western part of the Alnarp Valley is described by Mohrén (Fig 6, after Mohrén in Ekström 1953). According to Mohrén the complete sequence of strata is following:

12. Post-Glacial sediments

11. Glacial clay (Lomma clay) and glaciofluvial deposits

10. Baltic till (Younger Baltic or SW-till)

9. Intermorainic clay and sand

8. North-eastern till (NE-till)

7. Sand or silt layer (in the north-western part of the Alnarp Valley of more sporadic occurrence)

6. Stoneloss clay, silty, downwards transition to

5. Silt (Grävie sand), rich in glimmer, well sorted, with amber, brown coal-like pieces of wood and various tempered fossils in secondary (reworked) position. Arctic fossils are supposed to be primary.

4. Medium sand

3. Stone layer, "rullstenslagret", which can be interpreted as a rest of a more connected bed of stratum 2.
2. Local till with high content of carbonate.
1. Organogenous (or minerogenous) lacustrine sediments with a flora and fauna of warm or temperated type.

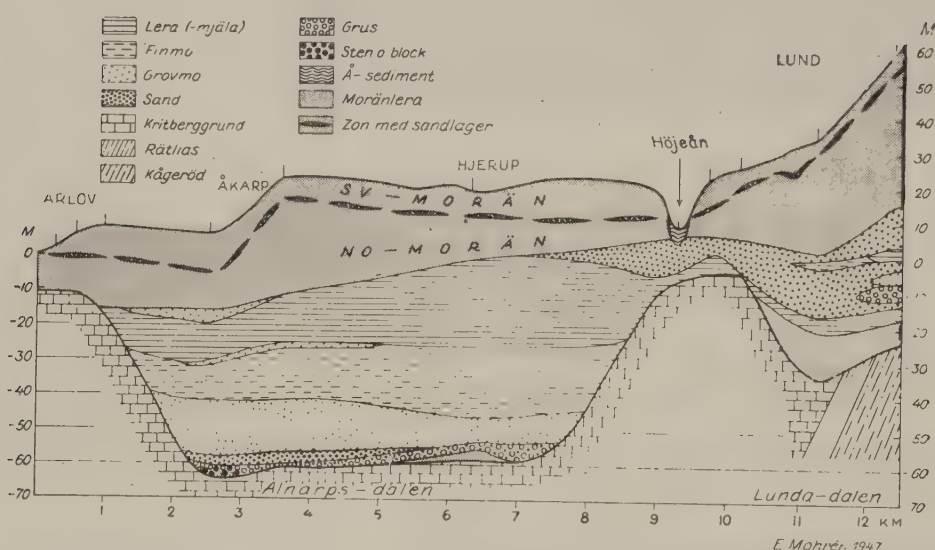


Fig 6. Cross section showing the Quaternary deposits of the Alnarp Valley at Arlöv - Åkarp - Lund (Mohrén in Ekström 1953, Fig 4).

K. Nilsson has discussed the problems of glacial geology in south-western Scania and lithostratigraphically studied the deposits of the Alnarp Valley (K. Nilsson 1973). According to him the Alnarp sediments are of interstadial origin, deposited probably during the Weichselian interstadial complex, corresponding to Upton Warren in England (Coope et al 1961) and Hengelo-Denekamp in the Netherlands (Zagwijn & Paepe 1968, van der Hammen et al 1971).

The dominating characteristic component in the Alnarp sediments is fine sand and/or coarse silt, so-called Gravel-sand (Holst 1911, Mohrén in Ekström 1953, K. Nilsson 1973), mainly composed of quartz > 90%. The content of carbonate

is very low, only a few per cent. In the typical Alnarp sediments the sand/silt layers become coarser downwards (sand, gravel, stones) and finer upwards (clay). Alnarp sediments are overlain by massive till beds (20 - 30 m) and sometimes also underlain by a till bed.

Nilsson published (K. Nilsson 1973) two preliminary radiocarbon datings of the organogenous material in silt and clay from different levels in the Hyby and Gärdslov cores (Hyby, at 69.1 - 69.6 m depth below surface, 36 995 $^{+2865}_{-2110}$ B.P. St 3157, Gärdslov, 80.33 - 80.83 m depth below surface, 32 730 $^{+2800}_{-2040}$ B.P. St 3158). These two datings together with a number of later datings will be discussed in 3.3.3. (p. 99). Also the stratigraphy of different till beds in the Alnarp Valley will be discussed more closely later (p. 96). Here only a very brief outline of the different till types in the Alnarp Valley is presented, mainly according to Mohrén and Nilsson (Mohrén in Ekström 1953, K. Nilsson 1959, 1971, 1973).

The oldest till found in the Alnarp Valley, occurs in the deepest part of the Tofthög-core and is by K. Nilsson assumed to be of Saalian age, indicating an ice-movement from the north (Drenthe-stage). In the southern part of the valley, sometimes also an so-called Old Baltic till with high content of Cambro-Silurian limestone (ice-movement from east - south-east) underlies the Alnarp sediments. Nilsson supposes that this till might represent the Younger Warthe-stadial of the Saalian glaciation (Cepek 1967, T. Nilsson 1972, p. 139). The till bed overlying the Alnarp sediments is assumed to be of the same origin (ice-movement from east - south-east), i.e. a Baltic till on account of its high content of Cambro-Silurian limestone. This till is supposed to correspond to the initial phase of the Weichsel II stadial in south-western Scania (Fig 7, after Lundqvist 1974). According to K. Nilsson during the first stadial of Weichsel glaciation (Weichsel I) the ice probably did not reach Scania at all. "The extension of Weichsel I is unknown and at present there is no conclusive evidence that the ice reached the southern part of the Baltic or adjacent areas" (K. Nilsson 1973, p. 18).

The thick till beds of Weichsel II contain intermorainic sediments and may (according to K. Nilsson 1973) represent an additional interstadial or at least an ice-oscillation during an early phase of Weichsel II. The till bed overlying these sediments shows an ice-movement from the north-east and is supposed to represent the main glaciation phase of Weichsel II stadial, represented by the so-called NE-till. In the southern and north-western parts of

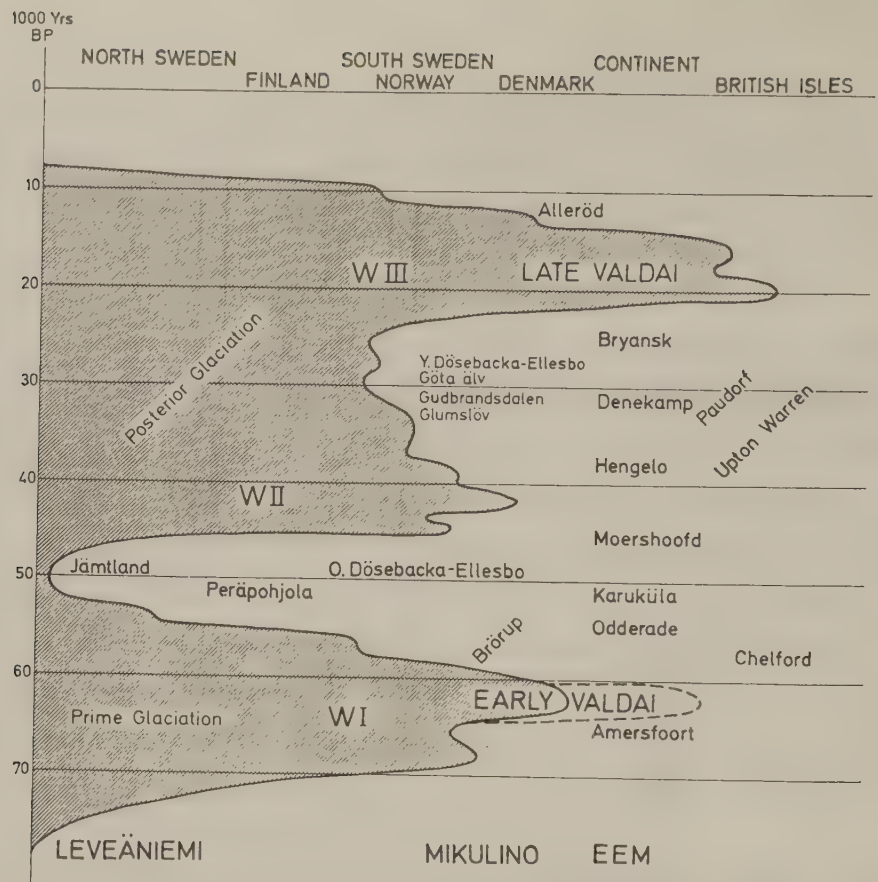


Fig 7. (after Lundqvist 1974, fig 2).

Fig. 2. Tentative diagram illustrating the extension of the Scandinavian ice over the European Continent throughout the Weichsel Glacial. (W stands for Weichsel or Würm.) The broken curve to the right in W I indicates a supposed extension westwards, although not southwards to the Continent. The main interstadials defined in various ways are also inserted according to radiocarbon datings (from the literature cited and available handbooks). Some differences in opinion as to the absolute and relative age of interstadials exist (cf. Mörner 1972, Fig. 11). It should be noticed that the glaciation curve indicates the — hypothetical — extension of the ice only, and is not directly comparable with similar climatic curves. It shows the glacio-stratigraphy. For instance, it takes some time for the ice margin to react upon a climatic amelioration, and even a severe deterioration may result in only a short-lived glacial advance. It is evident that there may have been many oscillations in southern Sweden. All these, as well as shiftings of the ice divide, may have resulted in different ice streams in Skåne. Because these have not been dated no attempt has been made to insert them in the diagram.

the Alnarp Valley, within the area of the Younger Baltic ice-stream, there occurs upon the NE-till a new bed of Baltic till so-called Low-Baltic, deposited by an ice from south-east-south. Between these two till beds (NE-till and Low-Baltic till or SW-till) thinner layers of sediments sometimes occur. On the top of the Low-Baltic till bed Late-Glacial sediments are found.

Mörner has briefly mentioned the three main separate till beds found in the Tofthög boring (Mörner 1969). He interprets them as all belonging to the Weichselian glaciation: the lowest till bed, so-called "Pre-Brörup till", represents Early Weichselian glacial (Andersen 1961); the sediments overlying the till correspond to the Brörup Interstadial (Andersen 1961); and the two upper till beds with interlying sediments belong to the Pleinglacial (Lower Pleniglacial, Interpleniglacial and Upper Pleniglacial) (van der Hammen et al 1967). Fig 8 and 9 show the Quaternary stratigraphy of Norden, according to Mangerud et al (1974).

Geo-chronologic	Era	Period	Epoch	Age
Chrono-stratigraphic	Erathem	System	Series	Stage
	Cenozoic	Quaternary	Holocene	Flandrian +
			Pleistocene	Weichselian +
				Eemian +
				Saalian s.l. +
				Holsteinian +
				Elsterian +
				'Interglacial III' 'Glacial B' +
				'Interglacial II'= Harreskovian +
				'Glacial A' +
				'Interglacial I'= Osterholzian
				Menapian Several stages in the Netherlands and North Germany
		Tertiary	Pliocene	
			Miocene	
			Oligocene	
			Eocene Paleocene	

Table 1. The generally used subdivision of the Cenozoic Erathem into systems and series. A provisional subdivision in stages for continental NW-Europe is also shown. In this column the horizontal lines indicate recognizable stage boundaries, and crosses stages represented in Denmark. References (for stages): S. T. Andersen 1965; Cepck 1967; Erd 1970; Goedeke et al. 1966; Grüger 1968; Menke 1968a, 1972; Zagwijn 1960; Zagwijn et al. 1971; Zagwijn 1973.

Fig 8. (after Mangerud et al 1974, Tab 1).

Table 3. Provisional chronostratigraphic subdivision of the Weichselian and the Flandrian in continental NW-Europe.

Geo-chronologic	Age	Subage	Chron	Definitions of boundaries in conventional radiocarbon years B.P.
Chrono-stratigraphic	Stage	Substage	Chronozone	
	Flandrian	Late Flandrian	Subatlantic	2500
		Middle Flandrian	Subboreal	
			Atlantic	5000
		Early Flandrian	Boreal	8000
			Preboreal	9000
		Weichselian	Late Weichselian	Younger Dryas
	Allerød			11,000
	Older Dryas			11,800
	Bolling			12,000
	Middle Weichselian		?	13,000
			Denekamp	
			Hengelo	
			Moershoofd	
	Early Weichselian		?	
			Odderade	
			Brørup	
			Amersfoort	

Fig 9. (after Mangerud et al 1974, Tab 3).

The latest publications mentioning the deposits in the Alnarp Valley, are the "Description to the Quaternary map Malmö NV" (Ringberg 1976) and "Radiocarbon-dated mammoth (*Mammuthus primigenius* Blumenbach) finds in South Sweden" (Berglund, B.E. et al 1976).

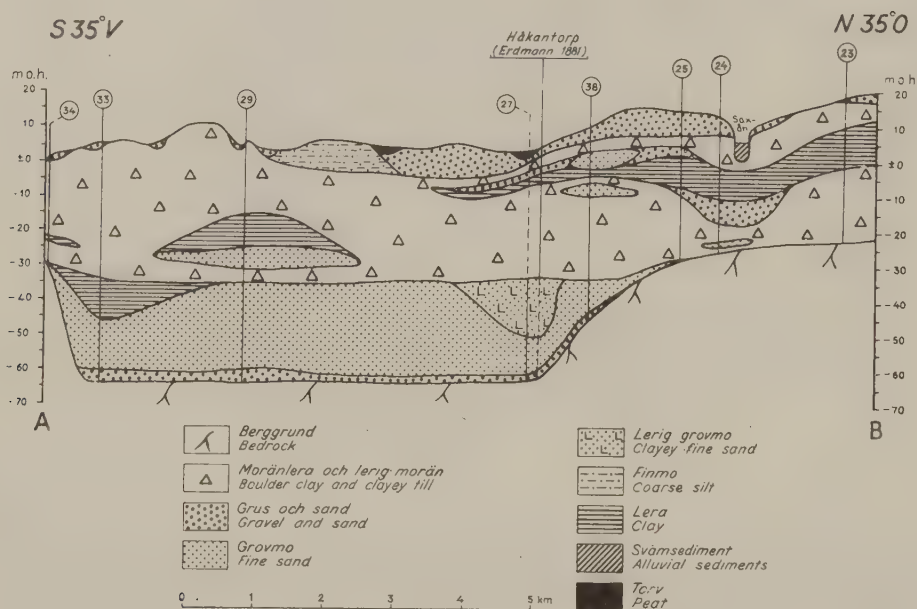


Fig 10. Cross section showing the Quaternary deposits of the Alnarp Valley, south of Landskrona (after Ringberg 1976, Fig 11).

A cross section through the Quaternary deposits of the Alnarp Valley, in the map area Malmö NW south of Landskrona shows that at least three different till beds with or without interlying sediments may overlie the Alnarp sediments (Fig 10 after Ringberg 1976). Lagerlund (p. 179 in Berglund et al 1976) follows the stratigraphy of Nilsson (K. Nilsson 1959, 1971, 1973) supposing the deposits of the Alnarp Valley in general to be of Middle Weichselian and Late Middle Weichselian age.

Ekström has compiled a map over the different till areas in Scania (Ekström 1940) and also a map of the surface soils (Ekström 1946). These two maps are shown in Fig 11 and Fig 12 to illustrate the heterogeneous composition of the surface deposits in Scania, particularly in its southern part. On the map (Fig 11) Ekström has put the boundary between the Baltic tills ("Baltic moraines" in the southern and western parts = SW-till) and the north-eastern tills ("North-East moraines" in the northern and eastern parts = NE till). The map of the surface deposits (Fig 12) is completed by the author, with the boundary

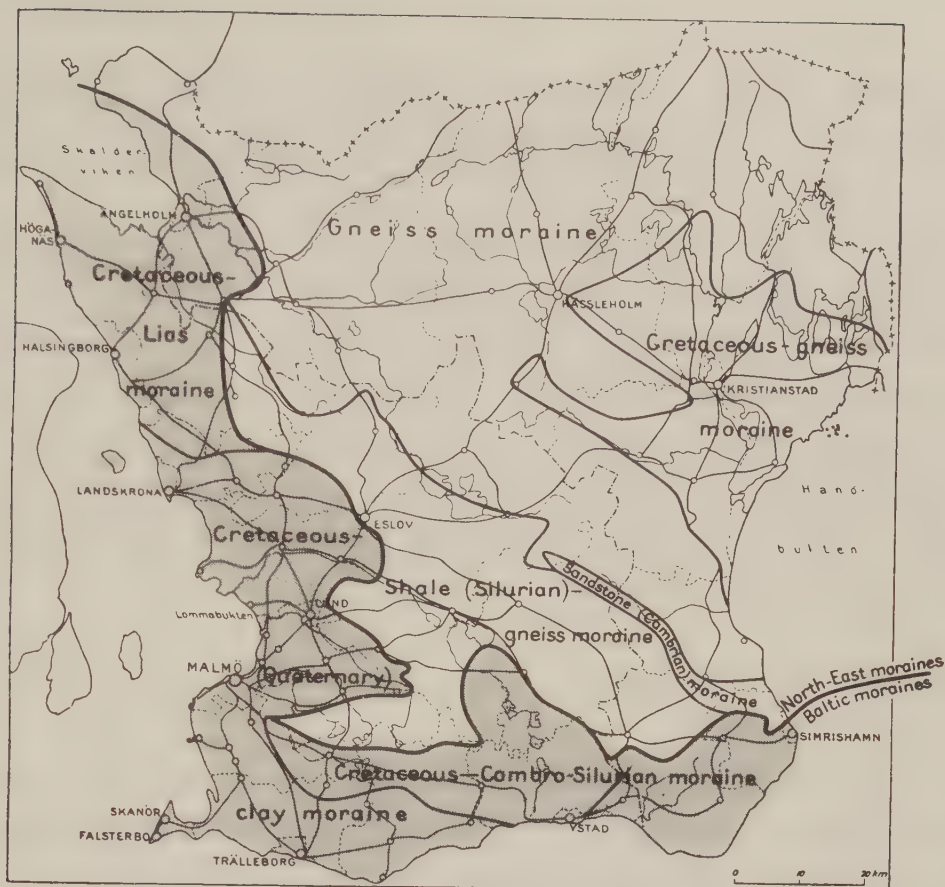


Fig 11. The different till regions of Scania (after Ekström 1940).



Fig 12. The surface soils of southern Scania (after Ekström 1946), completed with the boundary between the NE-tills and the Baltic tills, according to Ekström 1940 and the boundary of the Low Baltic till according to K. Nilsson 1959. The approx. extension of the Alnarp Valley and the sites of the core-borings (T, G, H) are shown on the map.

line between the SW-till and NE-till, the approximate extension of the Alnarp Valley and the sites of the three core-borings: Tofthög, Gärdslov and Hyby.

Beside the investigations concerning the glacial geology of southern Scania and particularly the Alnarp Valley mentioned above, there have been many other important contributions to the glacial geology, morphology and stratigraphy of southern Sweden during the last decades, e.g. Wennberg (1949), Johansson (1956), Möller (1959), E. Nilsson (1968), Hillefors (1969), Ringberg (1971) to name some of the most comprehensive ones. A very necessary outline of the Eem and Weichsel stratigraphy in Scania is in preparation by Berglund and Lagerlund (Berglund & Lagerlund in prep.)

1.3. The scope of the material

The scope of the material described below concerns the present investigation and related studies in connection with it. The main part of the material studied consists of bore-core samples from the three investigative borings in the Alnarp Valley, described in the following part of the present work. The total length of the three bore-cores is more than 300 m, the number of samples prepared is about 1 200 and the number analysed for their content of microfossils about 500.

It has taken much time to become familiar with the most common pre-Quaternary palynomorphs (pollen, spores, dinoflagellates, acritarchs, leiosphaerides), diatoms and silicoflagellates which occur reworked in the Alnarp deposits. Reference samples from Tertiary and Mesozoic deposits, taken from cuttings, well- and deep-borings in Scania and Denmark (Limfjorden-district, and Jutland) have been studied (Miller in K. Nilsson 1966 and Miller 1969).

Reference material from interglacial and interstadial layers in Denmark, northern Germany, the Netherlands, Belgium, France and Estonia has also been collected and prepared.

Interglacial and interstadial deposits in Sweden have been studied: Göta River Valley, western Sweden (Miller 1964), Leveäniemi, Lapland, northern Sweden (Miller in Lundqvist 1971), Nyköping, eastern Sweden (Miller & Persson 1973). Till stratigraphy at Stenberget, southern Scania according to microfossils (palynomorphs) has been applied (Miller in collaboration with Berglund et al).

Also samples from several well-borings through the Quaternary deposits in the Alnarp Valley (Dybäck, Abbekås, Skurup, Häckeberga, Marsvinsholm, Lemmeströ, Malmö 23) have been prepared and partly analysed for comparison with the core-boring samples. Material from gravel pits and other sections in the Alnarp Valley or adjacent areas (Örsjö, Glumslöv, Ven, Maglarp, Sunnanå, Fjellie and others) have been preliminarily analysed in co-operation with geologists in Lund (O. Andersson, L. Adrielsson, B. Ringberg, E. Daniel).

In connection with the Geological Survey's mapping of Quaternary deposits in south-western Scania, microfossil analysis has been applied on different till types as well as on interlying sediments (Miller and Robertsson in Ringberg 1976).

2. THE MICROFOSSIL INVESTIGATIONS (PALYNOMORPHS AND SILICEOUS MICROFOSSILS)

2.1. Previous research (review of literature)

2.1.1. Pre-Quaternary deposits

Concerning publications on pre-Quaternary microfossils (mainly siliceous microfossils and sporomorphs), several of the following papers have been of great value for the present investigation.

The study of Cleve-Euler on the marine diatoms and silicoflagellates of Lower Tertiary (Early Eocene) age found in clay at Åhus, the Kristianstad plain, north-eastern Scania (Cleve-Euler & Hessland 1948).

The publication of Ross on Upper Cretaceous pollen and spore bearing clay from Åsen, Lake Ivö, north-eastern Scania (Ross 1949).

The study of T. Nilsson on sporomorphs in a Mesozoic (Liassic) sapropelic rock from Sandåkra, northern Scania (T. Nilsson 1958).

The studies of Skarby on variations in Upper Cretaceous Norma-pollés (Extra-triporopollenites) types from north-eastern Scania (Skarby 1968) and on *Gleicheniidites* spores (Skarby 1964) have been of interest.

Kockel-Brosius has carried out investigations of palynomorphs in bore-samples of Liassic age from central Scania (Kockel-Brosius in Börlau 1965, pp 55 - 60).

During the last decade Tralau has contributed with several publications to the knowledge of microfossils in the Mesozoic deposits of Scania. He has studied the Jurassic microfloras at Eriksdal in Fyledalen, southern Scania, where he selected three stratigraphically important groups of microfossils. The first group is typical for Lower - Middle Jurassic age, the second group is characteristic for Middle Jurassic only, and the third group contains sporomorphs distributed from Middle to Upper Jurassic and continuing in Lower Cretaceous (Tralau 1968 a). In a survey of investigations about pre-Quaternary pollen analysis in Sweden, mainly in Scania, Tralau proposed that the age of the Kågeröd layers (assumed previously to be almost free of fossil), corresponds to Keuper (Trias), on account of the sparsely occurring but typical microflora (Tralau 1968 b). Tralau has also published a paper, where the stratigraphically most important Triassic (Rhaetian) sporomorphs of the Vallåkra layers in north-western Scania are described (Tralau 1975). The Middle Jurassic sporomorphs in the Höllviken-core have been described by Tralau and by Mahin (Tralau 1967, Mahin 1968). Tralau and Artursson have published their investigations on new Middle Jurassic pollen and spore floras of southern Sweden and Öresund (Tralau & Artursson 1972). Tralau also has presented preliminary results of studies on microfossils in flint boulders from Halland (Tralau 1972), where the microfossils indicate Upper Cretaceous to Lower Paleocene (Senonian and Danian) age. Moreover, Tralau has palynologically dated volcanic activity in the Ringsjön-Hässleholm area of northern Scania (Tralau 1973). The ash samples consisting of basaltic tuff contain a Lower Jurassic microflora.

Guy-Ohlson has studied the palynomorphs in the Jurassic layers of the Vilhelmsfält's boring (Guy 1971, Guy-Ohlson 1976). Contributing with several new species to the microflora, she has dated the layers known as the Vilhelmsfält Beds to be of Middle Jurassic age.

Lower Tertiary (marine Eocene) diatoms and silicoflagellates have been studied by the author in connection with the geological investigations concerning the Kristianstad plain, north-eastern Scania (Miller in K. Nilsson 1966, pp 13 - 15).

In clay samples from 18 borings (62 samples studied) Eocene diatoms and silicoflagellates occurred in 5 of the borings (8 samples). Quantitative analyses of samples with the highest diatom frequencies showed that the diatom floras in clay samples from different depths had almost the same composition and contained a large amount of fragments and frayed frustules. These qualities are characteristic for reworked material. According to Nilsson (K. Nilsson 1966, p. 19) the clay is glacial and at least in its upper part consists of boulder clay. Also in the middle till bed (boulder clay) in the Tofthög-core the frequency of Eocene siliceous microfossils is extremely high (Miller 1971, p. 516).

Concerning dinoflagellates the investigations of Kjellström have contributed with important information to the stratigraphical distribution of planktic microfloras in the Upper Cretaceous (Maastrichtian) and the Cretaceous/Tertiary deposits of Scania (Kjellström 1973 and in preparation).

The present revue of previous papers, dealing with pre-Quaternary microfloras in Scania, clearly shows that the number of publications concerning Lower Mesozoic palynomorphs has increased markedly during the last decade. It also emphasises that there is relatively little published about Upper Mesozoic and Tertiary microfossils (diatoms, pollen, spores and other palynomorphs) in Sweden. In contrast the palynomorphic literature in other countries is prolific. According to Manum (Manum 1967) there is one paper published per day. The hand-books and papers used for identification and grouping of palynomorphs are given on page 36 in connection with the description of analysis (2.2.3).

2.1.2. Pleistocene deposits

The publications concerning microfossils (pollen, spores and diatoms) in the Pleistocene deposits of the Alnarp Valley have been rare. The list of fossils Holst published (Holst 1911) deals mainly with macrofossils. Among the plant remains found are representatives of temperate (Upper Tertiary and/or interglacial) as well as northern-arctic tundra (interstadial) floras. In Holst's earlier works on the Late-Glacial (Alleröd) layers at Toppeladugård (Holst 1906, 1908) more complete lists including information on fresh water diatoms (identified by A. Cleve-Euler), other microalgae and also some pollen. Another paper of Holst (Holst 1907) deals with macrofossils in lumps of silt and fine

sand embedded in a lower till bed at the brickyard at Bjäresjöholm near Ystad. The plant remains found belong to a vegetation of tundra type. Concerning the Late-Glacial vegetation and finds of macrofossils in Scania the publication of Nathorst (Nathorst 1870, etc, see T. Nilsson 1935) are of great importance. Nathorst was also the first to find arctic plant remains at Alnarp.

G. Andersson's studies of peat bogs in southern Scania (G. Andersson 1889 etc) are classical. v. Post studied the Late-Glacial clays in Scania and was also the first one to apply pollen analysis in his investigations (von Post 1913, 1924, 1926). Larsson made pollen analysis on Late-Glacial clay (ice lake sediments) and pointed out the occurrence of Abies alba and Pinus cembra pollen grains in the clays at Svalöv (Larsson 1932 and Larsson in Ekström 1933). The fundamental studies of T. Nilsson (Nilsson, T. 1935 etc) on the Late-Glacial and Holocene vegetation development in Scania and his paper on current problems and lines of development in Swedish Quaternary geology (T. Nilsson 1959) have an outstanding position in connection with Quaternary biostratigraphy, particularly with regard to the Late-Glacial and Holocene epochs. Concerning the Pleistocene epoch, T. Nilsson has compiled the biological and geological development all over the world, including Scania and adjacent areas, in his book "Pleistocen" (T. Nilsson 1972). Mohrén has carried out investigations on the microfossil content in Late-Glacial sediments (Mohrén 1938) and published the stratigraphy of the Quaternary deposits in the Alnarp Valley (Mohrén, p. 19, 22 in Ekström 1953) including some information of micro- and macrofossils.

During the last decade B.E. Berglund and G. Digerfeldt have published several studies on Late-Glacial and Holocene biostratigraphy, paleoecology and vegetation development in southern Sweden (Berglund 1966, 1971, Berglund & Malmer 1971, Berglund & Digerfeldt 1970, Digerfeldt 1975). The pollen and diatom content in the uppermost till layers and Late-glacial to Pre-Boreal sediments at Skurup, adjacent to the Alnarp Valley has been studied by Robertsson (Robertsson 1973).

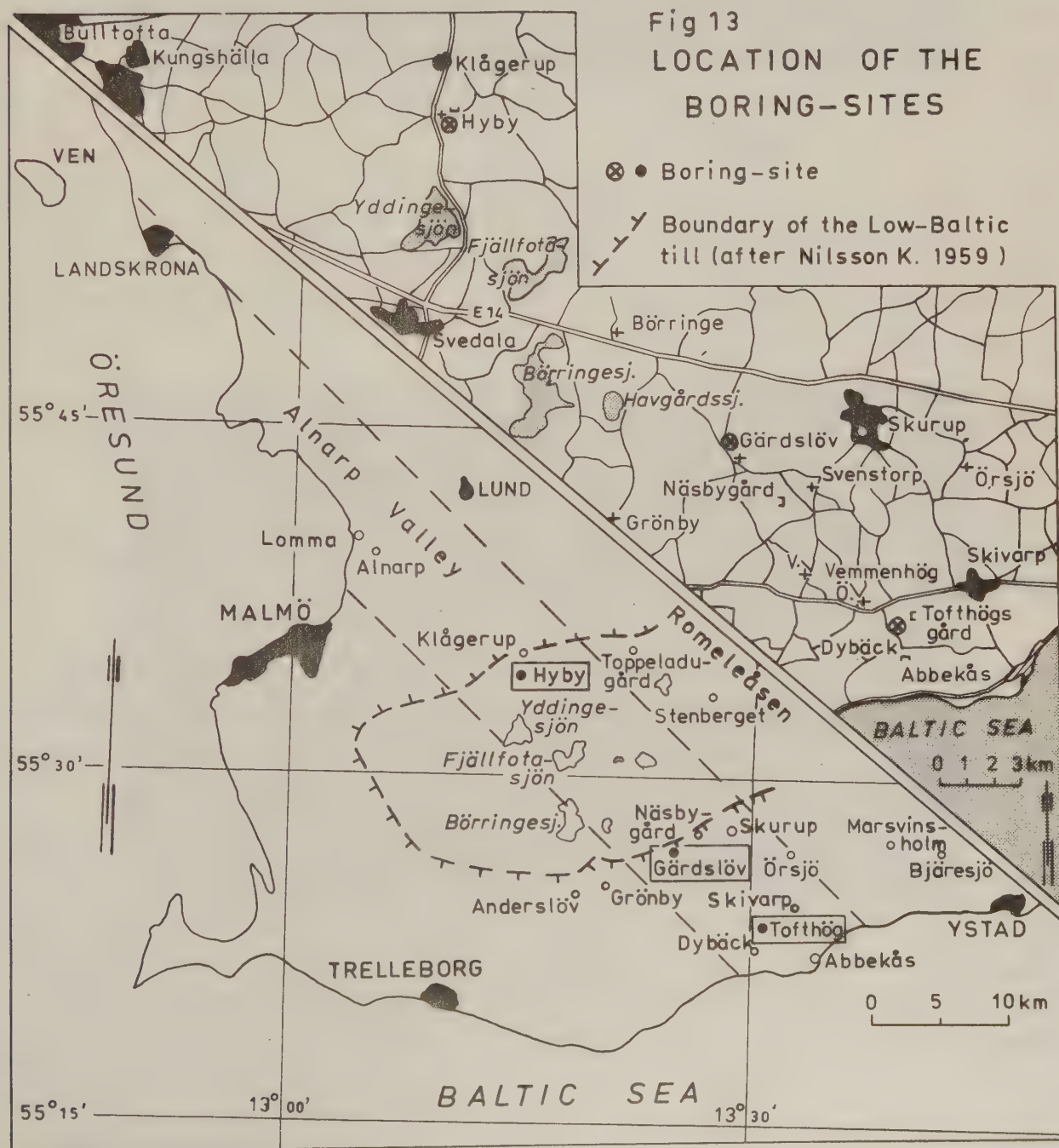
At the same time as the present investigation started and the problems with all the mixed Quaternary and pre-Quaternary pollen and diatom floras in the Alnarp deposits were of current interest, Andersen published his results about the "Pollen Analysis and Till Stratigraphy at Lindø, Denmark" (Andersen 1965 a) This paper indeed stimulated the author to continue her investigations

of the Alnarp material. The preliminary results of the efforts concerning the Tofthög-core, have been published (Miller 1971).

2.2. Material and methods

2.2.1. Location, stratigraphy and sampling

The core-borings have been carried out by the drilling firm Svenska Diamantbergborrnings AB during the following years: Tofthög 1964, Hyby 1965 and Gärdslov 1966. The technical data about the borings are published by K. Nilsson (K. Nilsson 1971, pp 496 - 498). The location of the boring-sites is shown in Fig 13 and in the general map Fig 1.



The Tofthög-core was drilled at the farm Tofthög, about 3 km west-south-west of the village Skivarp, map reference $55^{\circ}24'N$, $13^{\circ}31'E$. The altitude of the boring-site is 15.45 m above sea-level. The depth of the boring is 113.0 m. The bedrock (Danian limestone) lies at 110.2 m below the surface level. According to K. Nilsson (K. Nilsson 1971, p. 500) the sequence may be divided in the following way:

0	-	6.4 m:	Sediments. Varying grain-size
6.4	-	35.8	Boulder clay with separate sediment-layers (Photo, Fig 14)
35.8	-	64.4	Sediments. Varying grain-size (Photo, Fig 15, 16)
64.4	-	72.7	Boulder clay with sediment layers in the upper part
72.7	-	80.5	Sediments. Varying grain-size
80.5	-	107.2	Boulder clay with sediment-layers in the lower part (Photo, Fig 17)
107.2	-	110.2	Sediments, mainly fine-grained (Photo, Fig 18)
110.2	-	113.0	Limestone and flint (Danian) (according to K. Nilsson 1971, Cretaceous)

Fig 14 - 18 show the core strata (photographed by the author 1971) at 10.84 - 11.07 m (Fig 14), 38.57 - 38.81 m (Fig 15), 56.0 - 56.3 m (Fig 16) 93.0 - 93.2 m (Fig 17) and 109.0 - 109.2 m (Fig 18). Figs 10 - 12 are published by Nilsson (K. Nilsson 1971, Figs 2, 3 and 5).

Macroscopic remains of organogenous material (mainly pieces of fossil wood) were noted at the approximate depths of 51 - 52 m, 55 m and 76 m.

The stratigraphy and the lithological composition of the penetrated layers are shown in Fig 19 A (after K. Nilsson 1971, Plate 1).

The Hyby-boring was made at the farm Hyby (Fig 13), located between the lake Yddingesjön in the south and the village Klågerup in the north (map reference $55^{\circ}35'N$, $13^{\circ}16'E$). The altitude of the boring-site is 34.6 m above sea-level. The depth of the boring is 96.9 m. The bedrock (Danian limestone) lies at 95.5 m below the surface level. Of the penetrated strata 59.6 m (61.5%) could be taken up as core. The drilling was made in an old filled up well, at a place called "Mältan", where according to Holst (Holst 1911, p. 22) clay with muddy layers and "black mud" were found 33 - 79.4 m below the surface level (data from an old well-boring made in 1876). The "muddy layers" were partly refound below 69 m (69.1 - 87.0 m) depth.

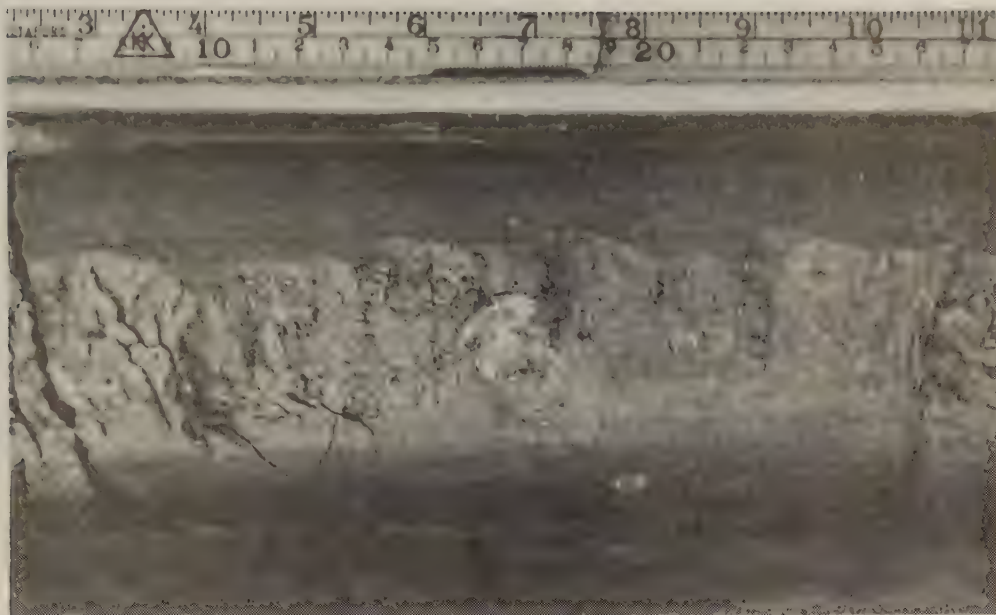


Fig 14. Tofthög-core. Till (boulder clay) between 10.84 and 11.07 m (published in K. Nilsson 1971).

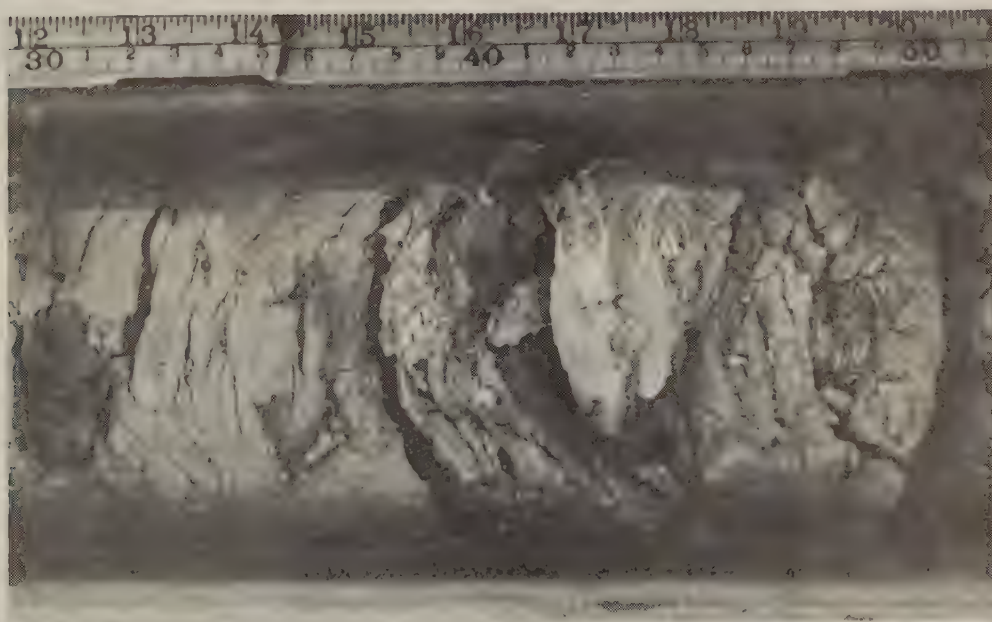


Fig 15. Tofthög-core. Clay between 38.57 and 38.81 m (published in K. Nilsson 1971).

Figs 16 - 18.
Toftthög-core.

Fig 16. Coarse sedi-
ments between 56.0
and 56.3 m (published
in K. Nilsson 1971).



Fig 17. Till (boul-
der clay) between
93.0 and 93.2 m.

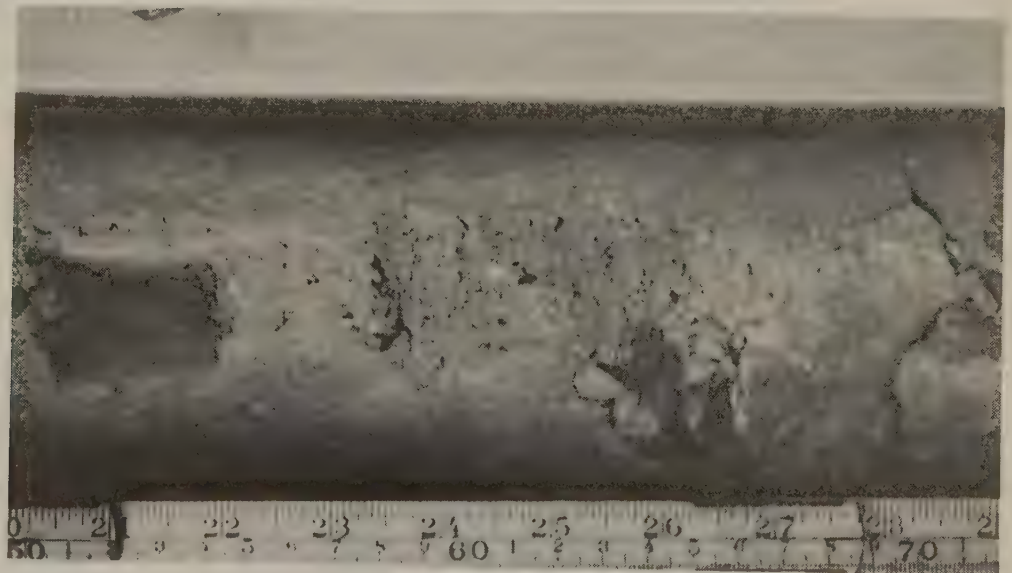


Fig 18. Silty sedi-
ments between 109.0
and 109.2 m.



The generalized stratigraphy of the penetrated strata according to Nilsson (K. Nilsson 1973, p. 12) is as follows:

0 - 32.4 m:	Till
32.4 - 59.2	Fine-grained sediments, mainly clay
59.2 - 69.1	Coarse-grained sediments. High content of Cretaceous rocks
69.1 - 70.8	Clay (Photo, Fig 20)
70.8 - 95.5	Silty sand and fine sand
95.5+	Bedrock (Danian limestone) (according to Nilsson, Cretaceous)

Figs 20 a, b show the strata at 68.85 - 69.28 m (photographed by I. Signorelli 1967). The stratigraphy and the lithological composition of the Hyby-core is shown in Fig 19 B (compiled by K. Nilsson 1967, not published).

Organogenous material, noted at the approximate depths of 34 - 38 m, 50 - 52 m, 69 m, 74 - 75 m, 87 m and 92 m, occurs most concentrated at 69.15 m as disturbed layer in the clay (cf Fig 20). At 35.5 m and 42 m it occurs as small grains of organogenous origin and at 50 - 52 m it has been noted as small pieces of coal. Between 74 and 85 m the silty sand contains gyttja. The main part of the fine-grained silty-sandy, partly muddy sediments at 70.8 - 95.5 m, could not be drilled up as core. The main part of the material was lost through the end-closer of the sampler and was instead taken up as mixed samples (so-called "slamprov") each representing 0.5 - 1.0 m of the core. For that reason there are two sample series of the boring between 71.7 and 95.5 m. The first one with very compacted core samples, consisting mainly of sandy (fine sand) minerogenous material which did not run through the bottom of the sampler, and a second series with mixed samples of finer silty material including gyttja (42 samples corresponding to 24 m sediment strata).

A more detailed stratigraphy of the sequences of strata in the Hyby-boring is as follows:

0 - 4.0 m:	Filling
4.0 - 21.7	Till, clayey
21.7 - 32.8	Till with interlying strata of clay and silt
32.8 - 33.4	Fine-grained sediments, mainly clay
33.4 - 37.0	Fine-grained sediments, mainly silt
37.0 - 42.0	Clay and/or boulder clay with thin layers of silt

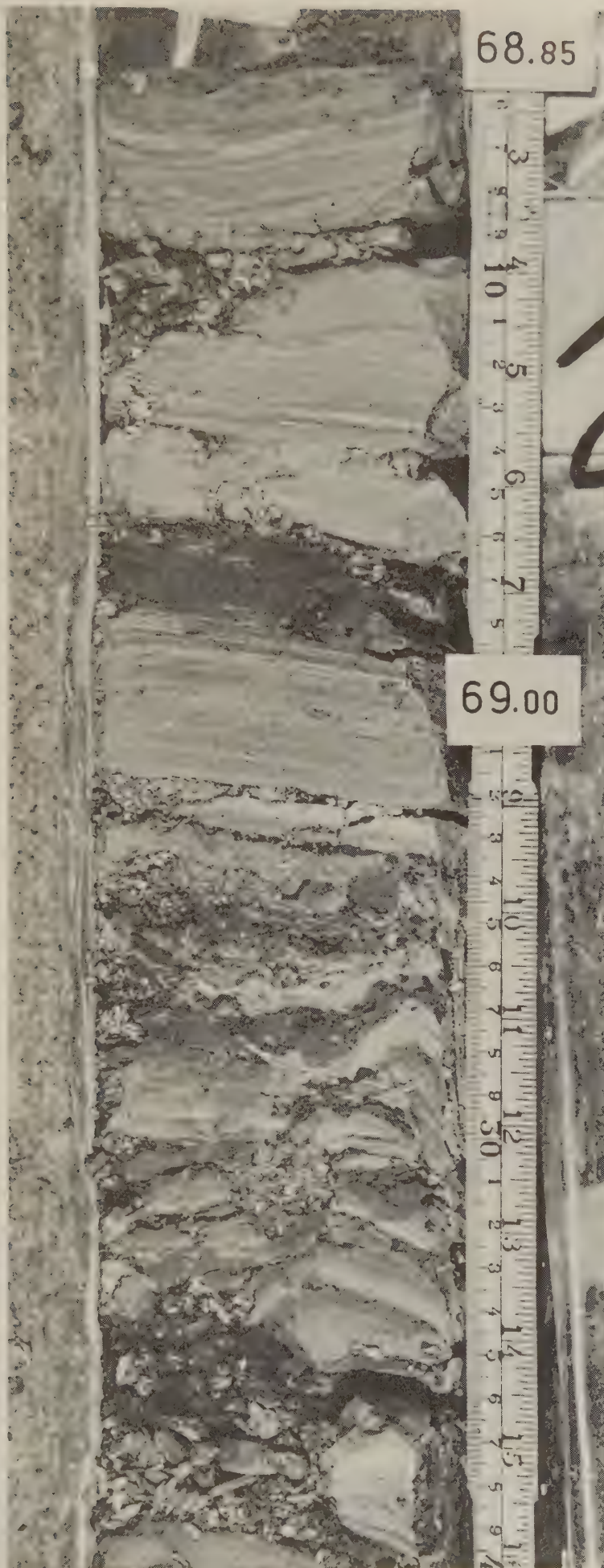


Fig 20 a. Hyby-core.
Clay microstratified
with silt, between
68.85 and 69.20 m.

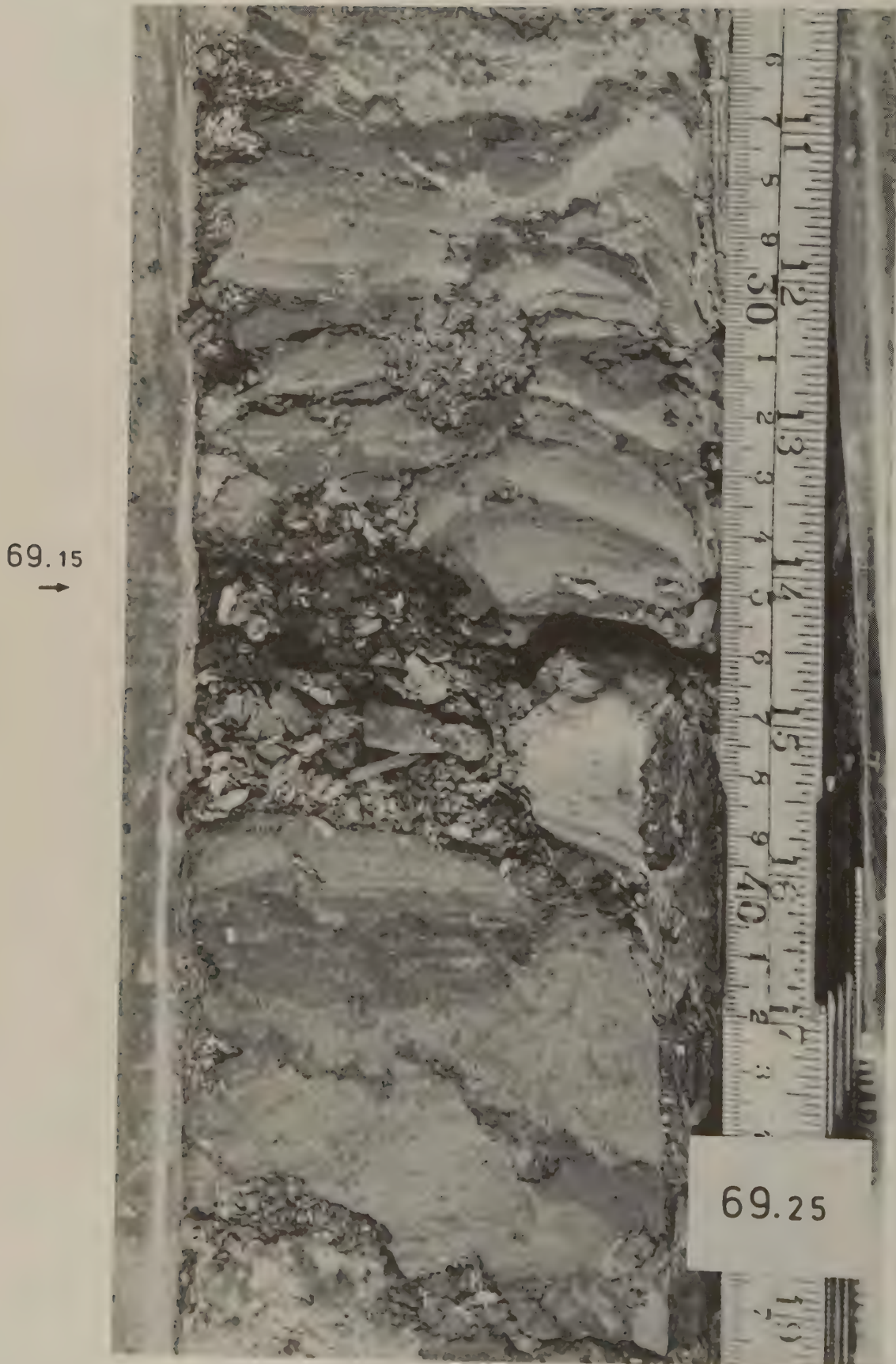


Fig 20 b. Hyby-core. Clay with disturbed stratification between 69.05 and 69.28 cm. At 69.15 m thin layer of organic material.

42.0 - 48.6 m:	Clay and silt
48.6 - 55.0	Fine-grained sediments, mainly sand and fine sand
55.0 - 59.2	Clay and/or boulder clay with thin layers of silt
59.2 - 68.5	Coarse-grained sediments, mainly stone and gravel (crushed Cretaceous rock)
68.5 - 71.6	Clay stratified with silt. Organic mat. at 69.15 m (Photo, Fig 20 a, b)
71.6 - 87.0	Silt and fine sand with some gyttja and sporadically coarser organogenous material
87.0 - 95.5	Sand and fine sand
95.5+	Bedrock (Danian limestone), cracked. Sand and gravel as crack-filling

The Gärdslov-core was drilled near to Getabäcksbron, 4.5 km west-south-west of the community Skurup, map reference 55°28'N, 13°25'E (Fig 13). The altitude of the boring site is 45.8 m above sea-level. The depth of the boring 107.2 m. The bedrock (Danian limestone) was reached at 106.5 m. Of the penetrated strata 87.8 m (82%) could be taken up as core. The site of the drilling was chosen according to the information given by Holst (Holst 1911, p. 24). In connection with an old well-boring, a layer of peat, 0.3 m thick, was noted there at 28 m below the surface level. This peat layer was not refound.

The generalized sequence of Quaternary deposits has the following stratigraphy (according to K. Nilsson, 1973, p. 12):

0 - 5.5 m:	Sand and silt
5.5 - 45.8	Till
45.8 - 65.6	Fine-grained sediments, mainly clay (Photo, Fig 21)
65.6 - 77.0	Till
77.0 - 82.4	Mainly silt (Photo, Fig 22, 23)
82.4 - 88.5	Clay
88.5 - 106.5	Silty sand and fine sand
106.5+	Bedrock (Danian limestone) (according to Nilsson, Cretaceous)

The stratigraphical and lithological composition of the Gärdslov-core is presented in Fig 19 C (compiled by K. Nilsson 1967, not earlier published).

Photographs (taken by I. Signorelli 1967) of the sediments at the depths of 59.87 - 60.25 m, 80.52 - 81.00 m and 81.35 - 82.00 m are shown in Figs 21, 22 and 23.

Figs 21 - 23.
Gärdslov-core



Fig 21. Fine-grained, stratified sediments, mainly clay, between 59.87 and 60.25 m.

60.00

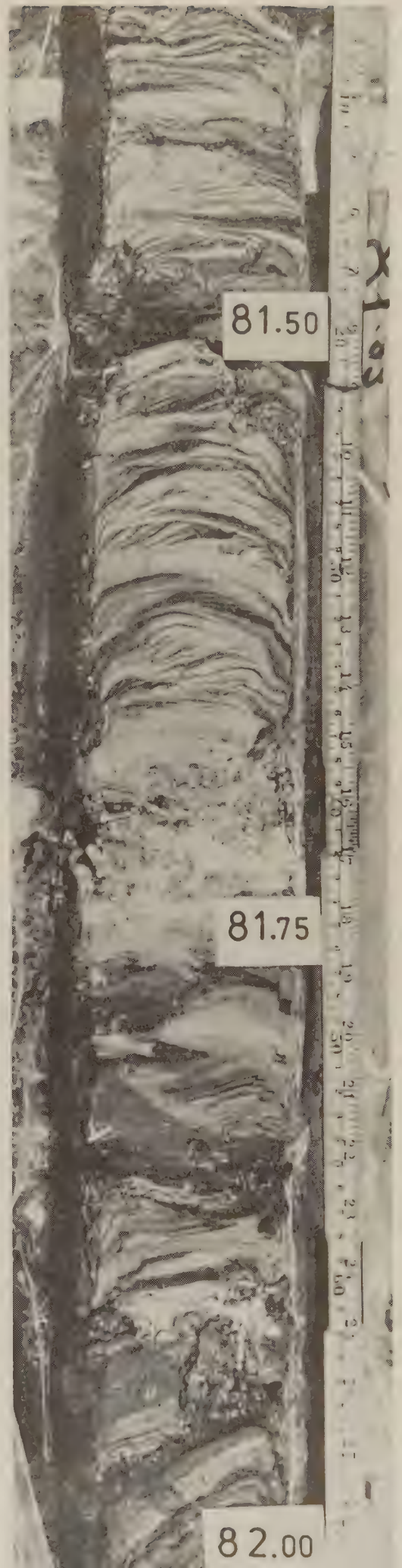
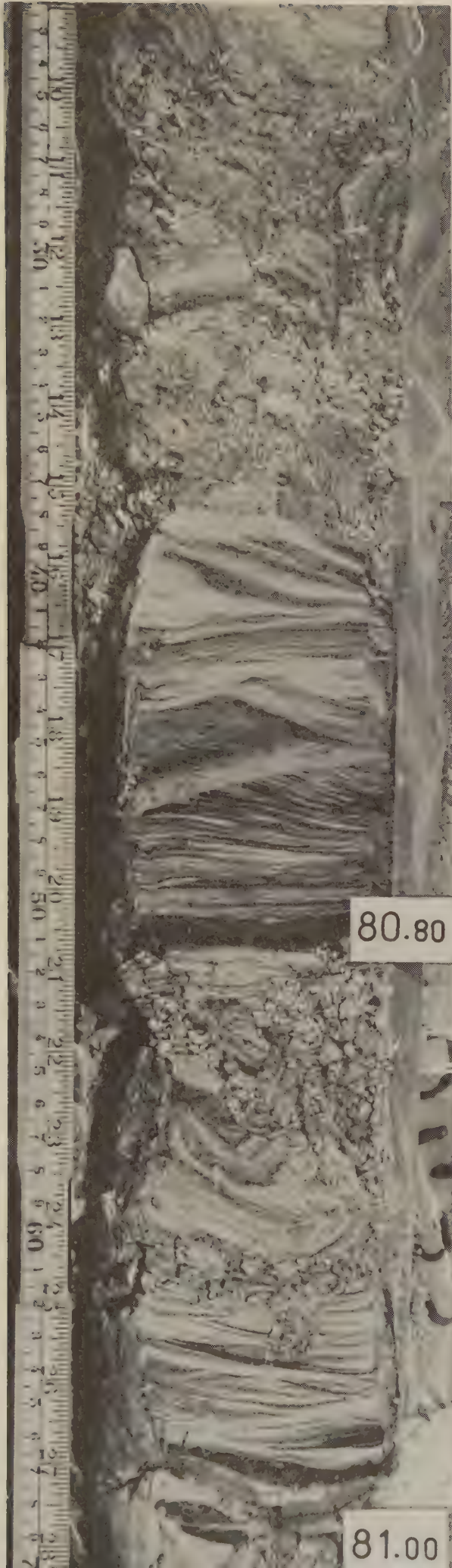


Fig 22. Fine-grained, silty sediments between 80.52 and 81 m. Cross-bedding, thin layers of organic material.

Fig 23. Fine-grained, silty sediments between 81.35 and 82.0 m. Cross-bedding, thin layers of organic material.



60.25



Organogenous material was noted at the approximate depths of 2 - 4 m, 11 m, 80 - 81 m, 82 m and 98 - 99 m as thin layers in the stratified silt and clay. Small grains of organogenous origin were noted at 88 - 89 m, 93 m and 100 m.

The general stratigraphy of the bore-cores was first preliminarily noted in the field in connection with the drillings and later at the Soil laboratory, SGU, where detailed stratigraphical examination and sampling for different types of analysis was carried out by Kaj Nilsson in collaboration with the author.

Samples intended for microfossil analysis were taken from each different layer with varying intervals, depending on the character and the homogeneity of the layers. The longest intervals were in homogeneous tills and coarse sediments (50 - 100 cm), shorter intervals were between samples taken of finer sediments (10 - 50 cm) and the shortest in layers with some content of organogenous material (2 - 5 cm).

Following samples of the investigative borings in the Alnarp Valley are registered and stored as reference samples at the Micropaleontological laboratory, SGU.

Reference No.

1 - 241	Tofthög-core	1.45 - 119.56 m	241 samples
242 - 718	Hyby-core	4.75 - 96.16 m	477 samples
719 - 760	Hyby-boring mixed samples	71.70 - 96.50 m	42 samples
770 - 1173	Gärdslov-core	1.60 - 107.00 m	404 samples
Total			1 164 samples

The number of samples prepared and/or analysed is as follows:

	Diatoms (Siliceous microfossils)		Pollen (palynomorphs)	
	prepared	analysed	prepared	analysed
Tofthög-core	241	36 (205)*	241	38 (135)
Hyby-core	220	107	162	55
Hyby-boring (mixed)	42	42	42	25 (70)
Gärdslov-core	127	122	97	62
	630	307 (205)	542	180 (205)
		519		385

* The numbers in parenthesis refer to preliminary qualitative analyses.

2.2.2. Preparation

All the samples were first treated with cold, dilute hydrogenous acid (10% HCl) to eliminate the lime and disintegrate the material.

The samples for palynomorph analysis, i.e. microfossils found in palynological preparations (for further see Kremp 1965, p. 111), were concentrated mainly according to the hydrofluoric acid (HF) method, first outlined by Assarsson and Granlund (1924), modified by Heinonen (1957), described by the author (Miller 1971, p. 509), combined with the modified acetolysis method of Erdtman (Faegri & Iversen 1964, p. 71).

The concentrate was mounted in glycerine (non-permanent slides) and glycerine jelly (permanent slides). The remaining concentrate residue is retained in corked plastic centrifuge tubes at the Micropaleontological laboratory, SGU.

In some cases the sample series have also been subjected to more effective concentration methods by means of heavy liquids (ZnBr_2) and percolation which have been carried out after the above mentioned HF + acetolysis method. This treatment is a somewhat modified version of the concentration method used at the laboratory for dinoflagellate and acritarch concentration.

The samples for siliceous microfossil analysis were concentrated by heating in a waterbath with 15% H_2O_2 , followed by repeated washing (for details see Miller 1964, p. 13). The residue was mounted in synthetic Canada balsam, Caedax (Bayer) with refractive index 1.55 and Mikrops (GBI Lab. LTD) with refr. index 1.63.

For all types of slides cover glasses of 24x36 mm size were used. All preparative work has been carried out by the staff at the Micropaleontological laboratory, SGU.

2.2.3. Analysis

Microfossil analyses were made using Reichert research microscopes (Zetopan) with phase contrast and automatic photographic equipment.

Diatom analyses were carried out under oil immersion and phase contrast at a magnification of x.1000.

For the identification of siliceous microfossils and as reference the publications of Benda (1965, 1972), Cleve-Euler (1951-55, 1948), Florin (1970), Gemeinhardt (1931), Grunow (1883), Heiberg (1863), Hirvas & Tynni (1976), Hustedt (1930, 1927 - 1966), Kitton (1870-71), Patrick & Reimer (1966), Proshkina-Lavrenko (1949), Schmidt (1874 - 1957), Schrader (1974, 1976), Schulz (1935), Stolley (1900), Strelnikova (1968, 1974), Wornardt (1969, 1971) were used.

The reference literature used for identification of pollen and spores were: Beug (1961), Cranwell (1964), Erdtman (1952, 1954, 1957, 1965, 1969), Erdtman, Berglund & Praglowski (1961), Erdtman, Praglowski & Nilsson (1963), Faegri & Iversen (1964), Florin (1969), Guy (1971), Ingwersen (1954), Kedves (1969), Klaus (1963), Kremp (1965), Krutzsch (1957, 1959, 1962-71), Menke (1976), Manum (1962), T. Nilsson (1958), Paleopalynologija (1966), Pflug (1953), Ross (1949), Skarby (1968), Thiergart (1940), Tralau (1968a), Tschudy & Scott (1969).

The publications of Eisenack (1967), Eisenack & Kjellström (1971-75), Kjellström (1971 a, b, 1973, 1976), Manum (1976), Morgan Smith (1920), Nygaard (1945), Sarjent (1967), Timofeev (1959), Tynni (1975) were used as main reference works for other palynomorphs.

2.2.4 Grouping of microfossils

The microfossil analysis data have been evaluated in various ways to ascertain the statistical treatment best applicable for stratigraphical purposes.

The following ways of grouping have been used concerning the total microfossil content.

A. Main groups of microfossils noted in:

a) Diatom slides: siliceous microfossils

Pleistocene fresh-water diatoms: centric (Centrales) and pennate (Pennales).

(Upper Cretaceous)-Lower Tertiary (Eocene) mainly centric marine diatoms.

(Upper Cretaceous)-Lower Tertiary (Eocene) silicoflagellates.

(Upper Cretaceous)-Danian diatoms and silicoflagellates, transformed and partly crystallized.

(Upper Cretaceous)-Lower Tertiary sponge spicules.

b) Pollen slides: palynomorphs

Quaternary (Pleistocene) extant, now (or during Upper Pleistocene - Holocene) living in northern Europe (cf Andersen 1965a, Iversen 1958).

Green-algae, mainly of genus Pediastrum, but also including genera Botryococcus, Scenedesmus, Staurostrum, Tetraëdon, Tetrastrum.

Spores

Pollen of coniferous and deciduous trees, shrubs and herbs.

Varia, mainly badly preserved, unidentified pollen and spores, but may also include other unknown palynomorphs (microplankton).

Pre-Quaternary, extinct, now (or during Upper Pleistocene - Holocene) not living in northern Europe.

Pollen, mainly vesiculate, inaperturate and aperturate pollen types (Kremp 1965).

Spores

Dinoflagellates, dinoflagellate cysts and acritarchs, abbreviated to Dino/Acri-group

Leiosphaerides, i.e. leiosphaeres and other leiosphaeres-like palynomorphs, abbreviated to Leio-group.

B. Pollen and spores:

a) Total: extant + Varia + extinct

Extant:

Pollen of coniferous trees (Picea, Pinus, Abies, Pinus cembra/mugo-type, pollen of Pinus silvestris-type distinguished) and

Pollen of deciduous trees (arboreal Betula, Alnus, QM: Quercus, Ulmus, Tilia, Fraxinus, Carpinus, Fagus).

Pollen of shrubs (Corylus, Juniperus, Taxus, Salix, Betula nana-type, Myrica, Frangula/Rhamnus-type, Ilex, Ephedra, Hippophaë, Ligustrum).

Pollen of herbs (Gramineae, Cyperaceae, Ericales, Artemisia etc).

Spores (Polypodiaceae, Lycopodiaceae, Equisetum, Sphagnum).

Varia: mainly badly preserved or unknown pollen and spores

Extinct:

Aperturate pollen-types

Upper Cretaceous-types (mainly Normapolles-group, Pflug 1953).

Paleocene-types (thiergarti, hexaradiatus etc types. Krutzsch 1957).

(Paleocene)-Eocene-types (Platycarya/microcoryphaeus, subhercynicus, terminalis, fusoid etc types).

(Lower)-Middle Tertiary pollen types (Juglans, Carya, Nyssa, Liquidambar, Pterocarya, coryphaeus, fallaxoid, exactoid, etc types). Inaperturate and vesiculate pollen-types and sporomorphs.

Lower Cretaceous and older (Jurassic, Triassic and Permian) sporomorphs (Classopollis, Circumpollis and old vesiculate types).

(Lower)-Middle-Upper Tertiary inaperturate types (Taxodiaceae, Cupressaceae, Sequoia, Sciadopitys).

Vesiculate-types (Pinus haploxylon, Tsuga, Podocarpus, piceoid, abiecoid-types).

Spores: (Gleicheniidites-, adrennoid-types, etc).

c) Extant pollen divided in components of

Pollen of trees (arboreal pollen)

Pollen of shrubs

Pollen of herbs (herbaceous pollen)

C. Siliceous microfossils were grouped according to A:a.

The (Upper Cretaceous)-Lower Tertiary diatoms further were divided after their degree of fragmentation into:

identified larger fragments and more or less whole frustules,

small fragments, unidentified (mainly belonging to the genera Coscinodiscus, Stephanopyxis, Triceratium and Hemiaulus).

This way of grouping was made to give an approximate estimate of the degree of reworking.

2.2.5. Construction of diagrams

The main part of the diagrams are presented as percentages of the main groups of microfossil counted, as so-called microfossil spectra. The microfossil frequency in different layers varies greatly. Often it is too low to be considered as statistically valid. In these cases the spectra show only an approximate tendency of microfossil composition. Samples with more or less similar microfossil spectra, belonging to the same lithostratigraphic unit, are presented as average spectra. The diagrams presented are constructed as:

A. Total microfossil spectra in

a. Diatom slides, where the results are presented as percentages of all the siliceous microfossils counted.

b. Pollen slides, where the results are presented as percentages of all the palynomorphs counted.

In these general diagrams (Figs 24, 27, 33) the lithology of the bore-cores is shown more in detail than in the other diagrams, where the lithology presented is simplified after Nilsson (K. Nilsson 1971, 1973). The columns in the diagrams are (from the left, e.g. see Fig 27)

1. Depth, given in metres below surface level, and lithology
 2. Organogenous material, marked in the parts of the core, where some organic matter has been ocularly noted.
 3. Radiocarbon datings, in years B.P.
 4. Loss on ignition
 5. Siliceous microfossil spectra: Diatom slides (diatom spectra). Siliceous microfossils grouped as mentioned in the text above (p 36).
 6. Total number of siliceous microfossils counted, ΣD = basic sum of siliceous microfossils (= 100%).
 7. Average frequency per transverse of each sample analysed and sometimes also as average values of several spectra and stratigraphical units.
 8. Stratigraphical units according to the microfossil spectra (diatom, diatom + palynomorphic and palynomorphic units).
 9. Palynomorphic spectra: Pollen slides. Palynomorphs grouped as mentioned in the text above (p 37).
 10. Total number of palynomorphs counted, ΣP = basic sum of palynomorphs (= 100%).
 11. Average frequency per transverse of each sample analysed and sometimes also as average values of the stratigraphical units.
 12. Depth, as in column 1, to facilitate the reading of the diagram.
- B. Pollen and Spore diagram (e.g. see Fig 28), where the sum of all pollen and spores counted corresponds to the basic sum = 100%.

In the parts of the cores where extant pollen and spores are dominant, the percentages are given for each sample analysed, in other cases, as average spectra of the stratigraphical units or parts (subunits) of them. The other palynomorphs: green-algae, dinoflagellates and achritarcs (Dino/Acri-group), leiosphaerides (Leio-group) are calculated as percentages of the total amount of counted pollen and spores.

- C. In the diagrams of extant pollen, e.g. see Fig 37, the basic sum corresponds to the number of extant pollen grains counted of trees, shrubs and herbs. Pollen of aquatic plants (AqP), spores and green-algae are calculated as percentages of the basic sum of ΣP extant.

The construction of special diagrams or parts of diagrams not mentioned here will be explained later on in the text, when interpreting the diagrams in question.

2.3. Results: Microfossil spectra

2.3.1. TOFTHÖG-core. The main part of the results has been published previously as a preliminary report (Miller 1971). Here some supplementary data will be presented together with the diagrams published earlier, in order to provide a better basis for comparison with the Hyby- and Gärdslöv-cores.

The description of the Toftthög-core contains:

2.3.1.1. Total spectra of siliceous microfossils and of palynomorphs (Fig. 24)	
a) Diatom. spectra	page 40
b) Palynomorphic spectra	" 41
2.3.1.2. Pollen and spores (Fig 25)	" 45
2.3.1.3. Siliceous microfossils, (Fig 26 A) list of species (Tab 1) ..	" 45

2.3.1.1. Total spectra of siliceous microfossils and palynomorphs (Fig. 24).

a) Diatom spectra. The content and the main composition of siliceous microfossils are presented as nine average spectra. As mentioned earlier (Miller 1971, p 515) all the siliceous microfossils found in the Toftthög-core are of Lower Eocene age or may in part be older. The division into average spectra is based upon the frequency of the frustules in the samples analysed and upon the percentage relation between the different groups of siliceous microfossils. The frequency values represent the average number of frustules and frustule fragments found per transverse of the slide (36 mm in length and approx. 0.1 mm in height) at a magnification of x 1000 (oil immersion).

Spectrum I. (110.65 m - Danian limestone with cracks, filled with silty sediments). The main part of the frustules consists of transformed, partly crystallized and dissolved older diatom frustules (82%), corroded silicoflagellates (12%) and sponge spicules (6%). The frustule frequency is low, about three frustules per transverse. Eocene diatoms are not present.

Spectrum II. (110.65 - 80.0 m - silty sediments and boulder clay with thin layers of sand in the lower part). Very poor in siliceous microfossils. No Eocene diatoms have been noted. A few fragments of sponge spicules, silicoflagellates and one older, transformed frustule fragment compose the average spectrum of eight samples analysed.

Spectrum III. (80.0 - 76.0 m - coarse sediments). The frequency of frustules is still very low, but in the composition of the spectrum, fragments of Eocene diatoms dominate greatly. No older transformed frustules have been noted.

Spectrum IV. (76.0 - 63.0 m - boulder clay with sandy silt in the lower part and thin sand layers in the upper part). Siliceous microfossils have very high frequency, in average 80 per transverse (varying between 28 and 154 in the five samples analysed). Eocene diatoms are predominant (65%).

Spectrum V. (63.0 - 59.0 m - sediments of varying coarseness). The average frustule frequency of the three samples analysed is still quite high (18), but the composition has changed. Eocene diatoms have decreased to 43% and sponge spicules increased to 39%.

Spectrum VI. (59.0 - 43.4 m - coarse sediments in the lower part, mainly sand in the upper part). Frustule frequency is low, about 3, in the five samples analysed. In the composition of the spectrum the older transformed frustules have increased to about 10%. Eocene diatoms occur with 47% and sponges spicules with 31%.

Spectrum VII. (43.4 - 39.4 m - mainly clay with sand in the lower part). The average frustule frequency increases to 9. In the composition of the spectrum the Eocene diatoms again are predominant with 60%. Older transformed frustules are not present. Sponge spicules occur with 35% and silicoflagellates have decreased to 5%.

Spectrum VIII. (39.4 - 16.0 m - clay, boulder clay and coarse sediments alternating with boulder clay). The average frustule frequency is low (3). Eocene diatoms and sponge spicules occur with about the same values (42%). Silicoflagellates have increased to 13% and older transformed frustules are represented again with a few percentages.

Spectrum IX. (16.0 - 0 m - boulder clay and sediments of varying coarseness). Frustule frequency increases slightly to 5 per transverse. Eocene diatoms predominate with 62%. Sponge spicules decrease to 23%, silicoflagellates are nearly constant (14%). Older transformed frustules are represented very sparsely (1%).

Stratigraphical remarks: The frequency of siliceous microfossils is extremely high in the boulder clay and in the sediments connected with the boulder clay between 76 - 58 m.

The strata from the bedrock up to the coarse sediments at 80 m depth lack Eocene diatoms. The highest percentages of Eocene diatoms (60 - 65%) occur in the boulder clays between 73.0 - 63.0 m and 16.0 - 6.0 m, and in the clayey sediments at about 40 m (39.4 - 43 m). The older transformed frustules have highest percentage values in the bedrock sample (110.65 m) and in the coarse sediments and sand (spectrum VI) between 59 and 43 m.

b) Palynomorphic spectra. The content and composition of the palynomorphs in the strata of the Tofthög-core are presented as ten stratigraphical units. In the main the division applied here corresponds to the earlier established so-called biostratigraphical division, published in the preliminary report on the Tofthög-core (MILLER 1971. pp 515 - 517). The palynomorph spectra are given for each sample analysed to show that in spite of the low and sometimes very low numbers of palynomorphs counted (basic sums) per sample, which not can be considered as statistically valid, the principal different features of the stratigraphical units appear quite clearly.

SIGNS : LITHOLOGY/SOILS AND ROCKS

	STONES		CLAYEY TILL
	GRAVEL		LIGHT BOULDER CLAY
	SAND		MEDIUM BOULDER CLAY
	FINE SAND		HEAVY BOULDER CLAY
	SILT		BEDROCK (DANIAN LIMESTONE)
	SILTY FINE SAND WITH GYTTJA		
	LIGHT CLAY		
	MEDIUM CLAY		
	HEAVY CLAY		

→
Fig 24. Tofthög-core.
Total spectra of sili-
ceous microfossils
and palynomorphs.

←
Key of the signs
used in the columns
of lithology.

The ten stratigraphical palynomorphic units are not described here in detail, only the most outstanding characteristics are pointed out. (For grouping see 2.1, p 37).

Unit 1 (110.65 - 106.4 m, sediments overlying the Danian bedrock and crackfilling in the rock).

Frequency: relatively high (varying between 3 - 15 per transverse) in the three samples analysed.

Dominant component: Dino/Acri group (60 - 85%), mainly dinoflagellates and dinoflagellate cysts. Extinct pollen is mainly represented by aperturate pollen types (10 - 25%).

Unit 2 (106.4 - c. 80 m, mainly boulder clay).

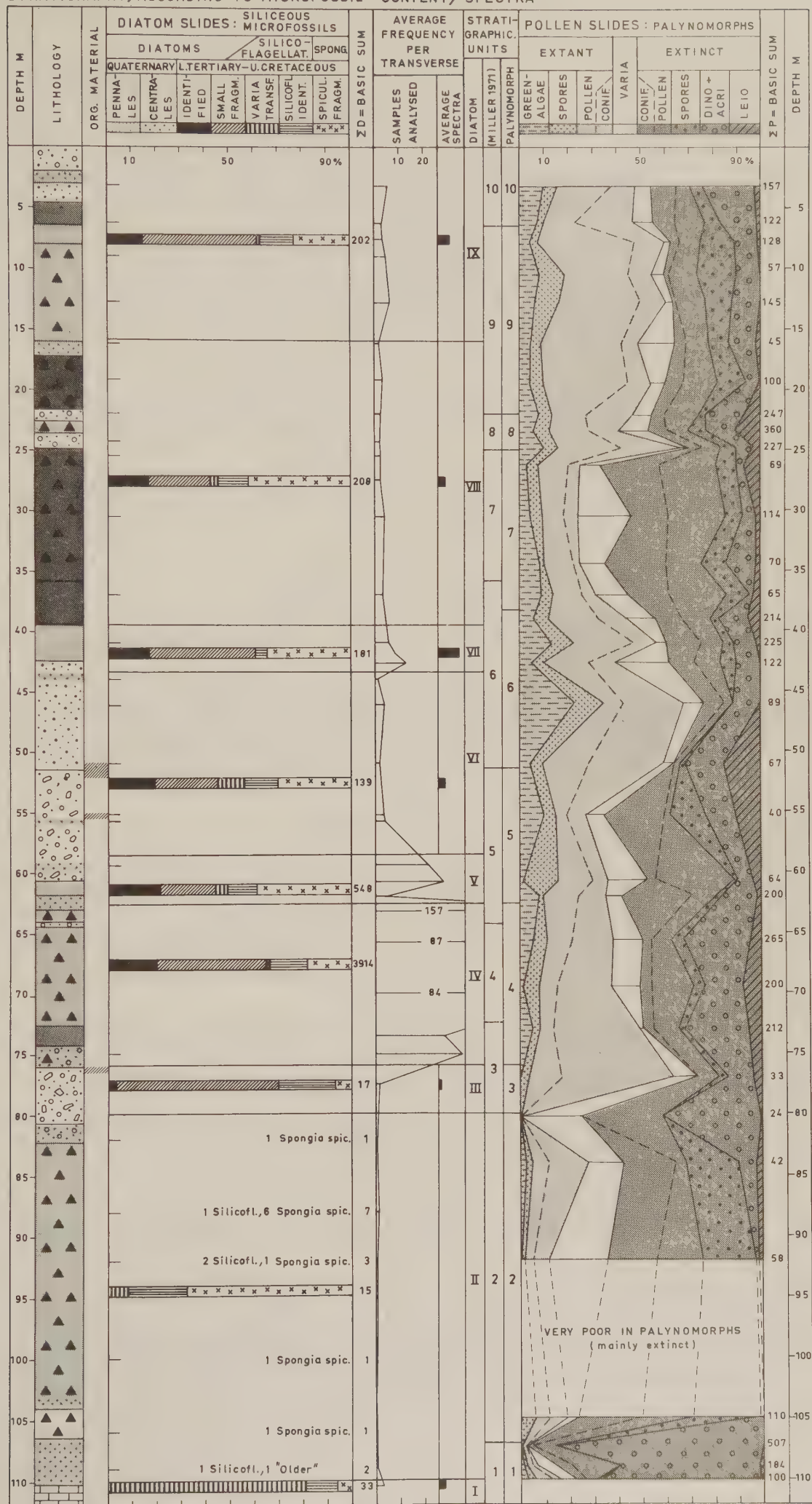
Frequency: Low to very low (2.5 - 0.8) in the five samples analysed (presented as four spectra).

Dominant component: extinct pollen (25 - 50%), mainly coniferous (vesiculate and inaperturate) types (20 - 30%). The content of extinct spores relatively high (20 - 25%). In the uppermost sample of the unit (80.25 m - gravelly sand) the composition of the extinct palynomorphs changes. Spores and coniferous pollen disappear. Dino/Acri-group increases to 40%. No extant palynomorphs have been noted.

Unit 3 (c. 80 - 76 m, coarse sediments).

Frequency: Very low (0.5) in the three samples analysed (presented as one spectrum).

Dominant component: Extant coniferous pollen (45%).



Unit 4 (76.0 - 63.0 m, mainly boulder clay).

Frequency: Increasing to about 4 (2.5 - 5.5) in the five samples analysed (presented as three spectra)

Dominant component: Extinct palynomorphs dominating (50%) mainly Dino/Acri-group (15 - 25%). Extant palynomorphs compose 40%, mainly coniferous pollen (20 - 35%) and extinct aperturate pollen (10 - 16%) Leio-group 5 - 8%

Unit 5 (63.0 - 51.5 m, sediments of varying coarseness).

Frequency: About 3 (varying between 1.8 and 5.6) in the three samples analysed.

Dominant component: Extinct pollen (35 - 40%). Extinct spores (15%) and Leio-group (10%) increasing upwards.

Unit 6 (51.5 - 38.0 m, sandy sediments and clay).

Frequency: Relatively high (3 - 7) in the five samples analysed.

Dominant component: Extant coniferous pollen (25 - 30%) and green-algae (22% at 46.1 m) in the lower samples (51.5 - 43.4 m) and extant pollen, mainly aperturate types (20%), in the upper samples (43.4 - 38 m). Leio-group almost missing in the middle samples.

Unit 7 (38.0 - 25.0 m, clay and boulder clay).

Frequency: nearly constant, about 3, in the four samples analysed

Dominant component: Extinct pollen (40 - 50%) including both coniferous types and others.

Unit 8 (25.0 - 22.0 m, coarse sediments and boulder clay alternating).

Frequency: nearly constant about 3, in the three samples analysed.

Dominant component: extant pollen (30 - 50%) both coniferous types and others. Slight increase of the Dino/Acri and Leio-groups.

Unit 9 (22.0 - 6.4 m, boulder clay with layers of fine grained sediments).

Frequency: varying between 1 and 4 in the five samples analysed.

Dominant component: extant pollen (40%), mainly aperturate types (deciduous trees 30%). Extinct spores relatively common (10 - 15%). Extinct pollen (10 - 15%), mainly aperturate types.

Unit 10 (6.4 - 0 m, sediments of varying coarseness)

Frequency about 2 in the two samples analysed.

Dominant component: extant pollen, both of coniferous and other types. Extinct pollen group increases slightly (20%), extinct spores decrease (5%).
Dino/Acri-group increases to about 20%.

Stratigraphical remarks: Four different types of till are clearly distinguishable according to the predominant component in the palynomorphic spectra:

1. Lowest till bed, (unit 2) 106- 82 m: Extinct pollen, with slight dominance of coniferous types. Extinct spores.
2. Middle till bed, (unit 4) 75- 64 m: Extant coniferous pollen types and Dino/Acri-group.
3. Upper till bed, lower part, (unit 7) 36 - 25 m: Extinct pollen, both coniferous and other types.
4. Upper till bed, upper part (unit 9) 21.5 - 6.5 m: Extant pollen, aperture types, mainly of deciduous trees.

2.3.1.2. Pollen and spores. The spectra of pollen and spores published earlier in the preliminary report on the Tofthög-core (Miller 1971, Figs 1 - 3, pp 510 - 512) are shown in Fig 25. The description of the diagrams (Miller 1971, pp 509 - 517) will not be repeated here.

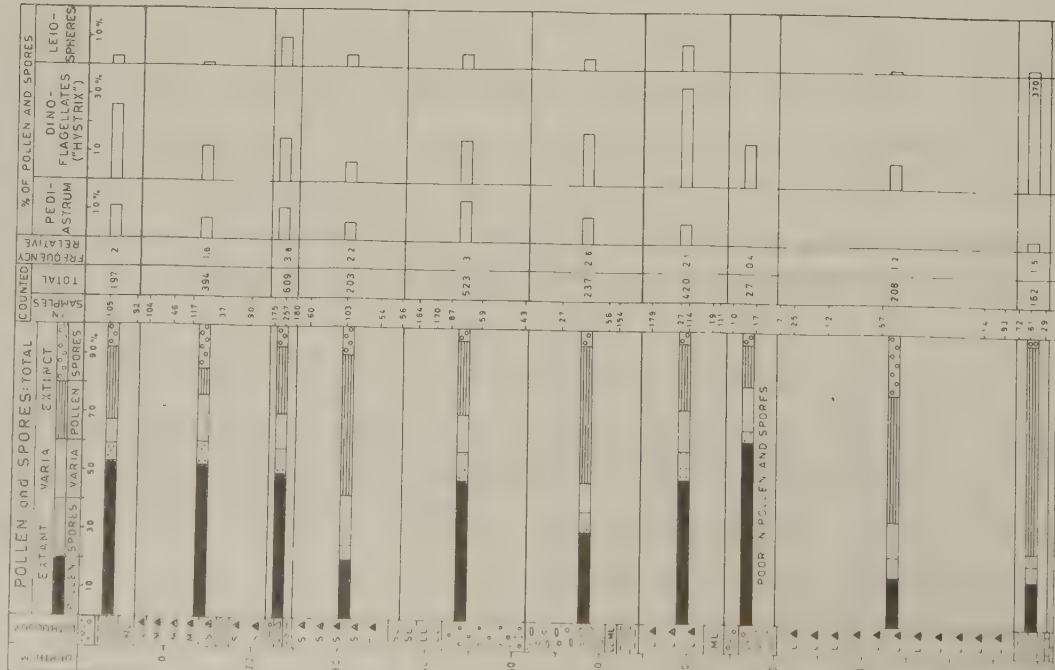
2.3.1.3. Siliceous microfossils The alphabetic list of siliceous microfossils occurring in the Tofthög-core is presented in Table 1, along with the stratigraphical distribution and approximate frequencies in the stratigraphical units.

The diagram showing the average frequencies of different groups of siliceous microfossils in the Tofthög-core is shown in Fig 26 A (Miller 1971, Fig 4, p 513)

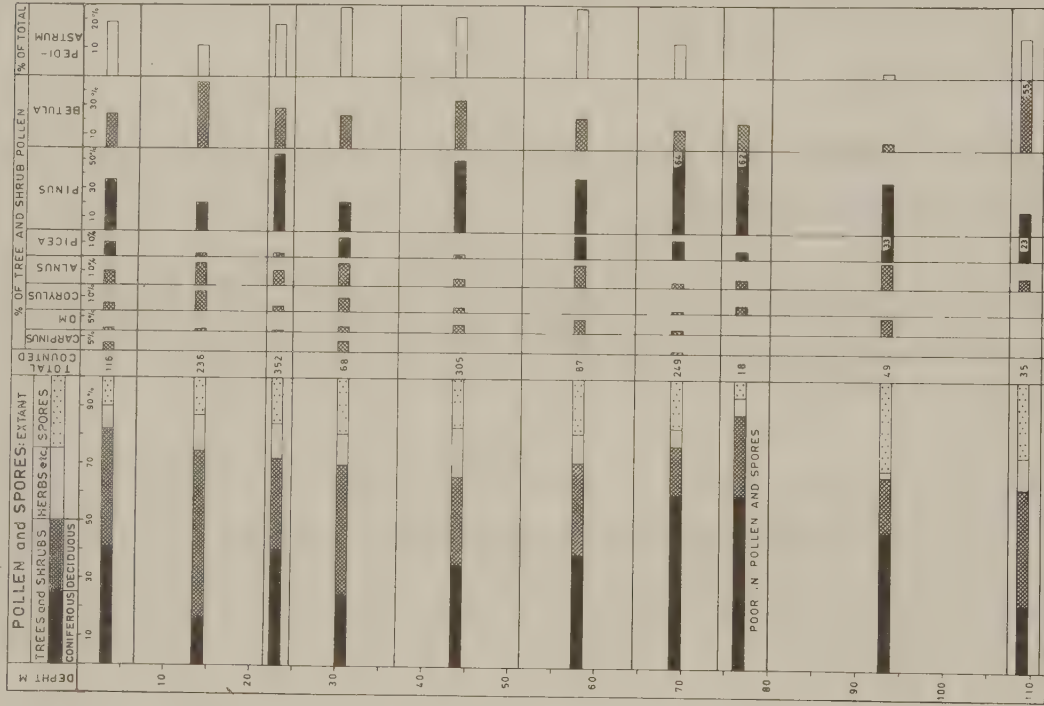
In the diagram and the list of species the results of 36 samples analysed are presented. All the remaining 205 samples prepared for diatoms have been qualitatively analysed. No Quaternary (Pleistocene) diatoms have been noted. The list (Tab 1) comprises about 70 pre-Quaternary marine taxa of siliceous microfossils (diatoms, silicoflagellates and sponge spicules).

Fig 25 A,B,C. Pollen and spore spectra of the Toftthög-core (after Miller 1971).

A. Total spectra of pollen and spores



B. Spectra of extant pollen and spores



C. Spectra of extinct pollen and spores



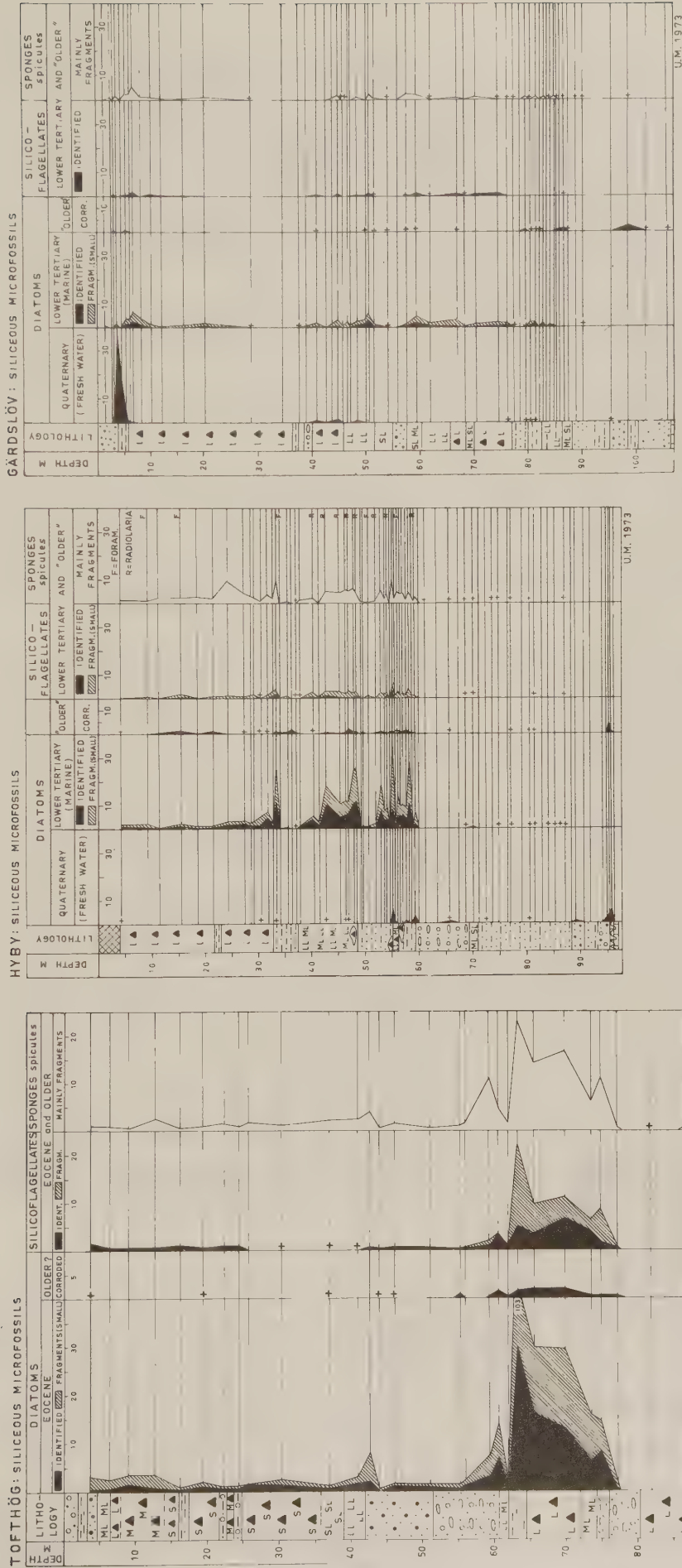


Fig 26 A,B,C. Frequencies per transverse of different groups of siliceous microfossils in A. Toftthög-core compared with B. Hyby-core and C. Gärdslov core.

2.3.2. HYBY-core. The description of the Hyby-core contains: page

2.3.2.1 Total spectra of siliceous microfossils and palynomorphs (Fig 27).....	50
a) Diatom spectra, b) Palynomorphic spectra	
2.3.2.2. Pollen and spores.....	56
a) total pollen and spore spectra of the whole core (Fig 28 A,B)	
b) extant pollen spectra of the fine-grained sediments 68.5 - 86.0 m (palynomorphic unit 3:2), (Fig 29, 30)	
c) extant pollen spectra of the fine-grained sediments 31.5 - 48.5 m (palynomorphic units 6 and 5), (Fig 31).....	64
2.3.2.3. Siliceous microfossils, (Fig 26 B, Tab 2,3) concerning mainly Pleis- tocene diatoms.....	65
a) in the sediments below 71.6 m (diatom units 3 a and 3+1) (Tab 5, Fig 32)	
b) in the mixed sediments and boulder clay 55.0 - 59.2 m (diatom unit 4 a (Tab 4,5)	
c) in the sediments 42.0 - 48.6 m (diatom unit 5)	

The detailed sequences of strata in the Hyby-core are shown in the total microfossil diagram, column of stratigraphy (Fig 27). The core samples have been analysed for their content of siliceous microfossils and palynomorphs to distinguish the main stratigraphical units with regard to their microfossil content. The frequency of microfossils in the samples is in general very low, except in the fine-grained sediments between 86.0 and 68.5 m and between 42 and 31.5 m. For that reason in the parts of the core, poor in microfossils, the pollen and spore spectra (Fig 28) are merely presented from calculations from the total sum of pollen and spores. In the fine-grained sediments named above, where the content of pollen and spores is higher, separate diagrams of the extant group are shown. (Fig 29 A,B, 30, 31).

Of the fine-grained sediments below 71.7 m two parallel sample series have been analysed. The first one representing the core samples and the second one representing the mixed samples ("slamprov"). The results are presented as parallel diagrams (Fig 29 A and B).

The content of siliceous microfossils is shown as spectra of different stratigraphical units (Fig 27). The spectra with about the same composition are grouped



Fig 27. Hyby-core. Total spectra of siliceous microfossils and palynomorphs.

in diatom units. An alphabetic list of the siliceous microfossils noted in the Hyby-core and their distribution and frequency in the different strata is compiled in Tab.2. The frequency of the different groups is shown in Fig 26 B.

In the mixed samples of the fine-grained sediments at 71.7 - 96.5 m. a relatively rich lacustrine diatom flora is present. A separate diagram (Fig 32) and an alphabetic list of species (Tab 3) illustrate the composition, distribution and frequency of siliceous microfossils in the mixed samples in more detail.

The main representatives and the composition of the different Pleistocene diatom floras occurring in the strata of the Hyby-core at 55.05 m + 58 - 59 m and 95.5 - 96.2 m are presented in the Tables 4 and 6. The identified taxa of the Lower Tertiary (marine Eocene) diatom flora and other siliceous microfossils occurring in the samples 55.05 and 58 - 59 m are listed in Table 5.

2.3.2.1. Total spectra of siliceous microfossils and palynomorphs.

a) Diatom spectra. According to the content and the main composition of siliceous microfossils, shown in the spectra (Fig 27), the strata of the Hyby-core are divided into 6 different stratigraphical diatom spectra units (3, 4, 5, 6, 7 and 8) comparable with the diatom spectra III - VIII of the Tofthög-core. The units 3, 4 and 7 are divided in subunits a and b. Spectra I and II of the Tofthög-core, characterized by absence of Eocene diatoms, are not found in the Hyby-core. Eocene diatoms are present also in the lowermost samples analysed.

Spectra unit 3 (96.0 - 59.2 m)

Subunit 1(+3): (96.0 - 89.75: bedrock, Danian limestone, with cracks filled with sand and gravel 96.0 - 95.5 m., sand and silt 95.5 - 89.75). In the lowermost spectrum (96.0 - 95.5 m) the Danian limestone is represented by the transformed diatoms and silicoflagellates (53%). Eocene diatoms are present with a few percentages. Pleistocene fresh-water diatoms compose the remaining 43%, mainly alkaliphilous species with several representatives of the so-called clear-water flora (i.e. *Cymbella sinuata*, *C. aspera*, *C. cuspidata*, *Opephora martyi*, *Cyclotella comta* v. *radiosa* and *Melosira arenaria*), presented in Tabel 6. In the sand and silt between 95.5 and 89.75 m the only siliceous microfossils noted are the transformed ones, probably originating from the Danian bedrock.

Subunit 3a: (89.75 - 71.6 m, silt and fine sand with some gyttja). The content of siliceous microfossils very low. Beside the Pleistocene diatoms, mainly clear-water forms (Melosira arenaria, M. islandica, Cyclotella comta v. radiosa, Stephanodiscus astraea, Navicula jentzschii, Cymbella prostrata) even all the other groups of Upper Cretaceous-Lower Tertiary siliceous microfossils are represented. The transformed frustules compose 15 - 20% of the total siliceous microfossil content.

Subunit 3 b: (71.6 - 59.2 m: clay, 71.6 - 68.5 stone and gravel 68.5 - 59.2 m.) Very poor in siliceous microfossils. The transformed frustules have almost disappeared. Pleistocene diatoms occur only as a few fragments. The main part of the frustules noted are fragments of sponge spicules and taxa belonging to the Eocene marine flora.

Spectra unit 4. (59.2 - 48.6 m).

Subunit 4a: (59.2 - 52.4 m boulder clay and/or clay). Content of siliceous microfossils high with an average frequency approx. 20 per transverse. Main component: Eocene diatoms (60 - 65%). Identified taxa are listed in Tab 5.

Pleistocene diatoms compose about 8% of the spectrum. They are mainly represented by acidophilous species of genera Eunotia, Frustulia, Pinnularia and Tabellaria (Tabel 4).

Subunit 4b: (52.4 - 48.6 m, mainly silt and sand. Content of siliceous microfossil low (average frequency approximate 2). No Pleistocene diatoms noted. Main groups: Eocene diatoms and sponge spicules, both about 40%. Transformed frustules compose 12% of the spectrum.

Spectra unit 5. (48.6 - 39.0 m, silt and clay with lumps of boulder clay in the upper part). High content of siliceous microfossils. Average frequency: approx. 20 per transverse (varying between 20 and 30 in the lower and middle part, and 5 - 10 in the upper). Main component: Eocene diatoms (60 - 65%). Transformed frustules occur only in small percentages. Of Pleistocene diatoms some marine species are noted in the clayey, silty sediments between 42.0 and 48.6 m (see page 66). In this part of the core silicoflagellates are quite frequent, 23% of the spectrum.

Spectra unit 6. (39.0 - 33.4 m, mainly silt, probably with some boulder clay in the lower part, 39.0 - 37.0 m). Poor in siliceous microfossils. Average frequency: 1 - 2 per transverse. Main components: transformed frustules (37%) and of sponge spicules (35%). Eocene diatoms occur with 15%. One fragment of Pleistocene diatoms noted Pinnularia sp.)

Spectra unit 7. (33.4 - 21.7 m).

Subunit 7a: (33.4 - 30.0 m, mainly clay and boulder clay). Content of siliceous microfossils high. Average frequency: approx. 15 per transverse. Main component: Eocene diatoms (60%). Content of transformed frustules low (1 - 2%). One Pleistocene species noted (Diploneis smithii).

Subunit 7b (30.0 - 21.7 m, till interlain by clay and silt.) Content of siliceous microfossils still quite high. Average about 10 per transverse. Main component: sponge spicules (50 - 70%). Transformed frustules are almost lacking. No pleistocene diatoms noted.

Spectra unit 8. (21.7 - 4.0 m, mainly clayey till). Content of siliceous microfossils quite low. Average 5 per transverse. Sponge spicules dominate (35 - 68%). Transformed frustules are more frequent in the lower part of the unit (15 - 18%), silicoflagellates in the middle part (22%) and Eocene diatoms in the upper part (20%). Pleistocene diatoms are noted as a few pennate fragments, impossible to identify.

Stratigraphical remarks: In the Hyby-core two main types of till can be distinguished by means of siliceous microfossils. The upper more compact and homogenous till type (21.7 - 4 m) which has a low content of siliceous microfossils and a lower one 59-39 m, which occurs mainly as lumps and thinner disturbed beds of boulder clay, and has a high content of siliceous microfossils of Eocene age. Sporadically also it has quite a high content of Pleistocene, mainly acidophilous diatoms, in its lower part, 59 - 55 m, upon the coarse sediments.

The thin layer of boulder clay at 38 - 37 m has very low content of siliceous microfossils and probably belongs to another ice-stream.

The till between 33.4 - 21.7 m is interlain by silt and clay. The content of siliceous microfossils is markedly higher than in the upper till. It may be distinguished as a third till-type or an intermediary type between the upper and lower till types.

The sediments of the Hyby-core between 39 m and 33.4 m are poor in siliceous microfossils, but show a clear influence of the local bedrock (Danian), represented by the transformed frustules. The sediments between 71.6 and the underlying bedrock. (95.5 m) may be characterized in the same way. But moreover they also contain Pleistocene fresh water diatoms with many representatives of the clear-water flora.

The coarse sediments between 69.1 and 59.2 m are very poor in siliceous microfossils. The transformed frustules are almost absent. According to (K Nilsson 1973) the coarse sediments have high content of Cretaceous blocks. With regard to the content of siliceous microfossils, the block material has to be of another origin than the immediately underlying Danian bedrock. (This statement is valid only on the assumption that the transformed frustules originate from the immediately underlying bedrock.)

The occurrence of an acidophilous Pleistocene fresh water diatoms together with a Eocene marine flora between 55.0 and 59.2 m is remarkable.

The occurrence of some Pleistocene marine diatom species in the sediments between 42 and 48.6 m is the only more obvious marine influence of Pleistocene age, noted in all the material analysed from the Alnarp Valley.

b) Palynomorphic spectra (Fig 27). The content and composition of palynomorphs in the strata of the Hyby-core are presented as 5 stratigraphical palynomorphic units, named 3, 4, 5, 6 and 7, comparable with corresponding units in the Toft-hög-core. Unit 3 is divided in three subunits 3:1, 3:2 and 3:3. Unit 7 is divided in two subunits 7:1 and 7:2. In the parts of the core where the content of palynomorphs is low, the average spectra of the unit are calculated. In the silty sediments between 36.5 and 34 m (middle part of unit 6) and between 83 - 68.5 m (unit 3:2), there the content of palynomorphs is higher, the spectra are calculated for almost each sample analysed.

Unit 3 (96.0 - 59.2 m).

Subunit 3:1 (96.0 - 89.75 m, sediments overlying the Danian bedrock and crack-filling in the rock, mainly sand gravel and silt).

Frequency: Average frequency relatively high, 5 for the two samples analysed.

Dominant component: Dino/Acri-group (50%), mainly dinoflagellates and dinoflagellate cysts.

Extinct pollen and *Varia* compose about 45%. The content of extinct spores is low (1%). Extant pollen not noted. Leio-group is present in small percentages.

Subunit 3:2 (89.75 - 68.5 m, mainly silty sediments with some gyttja and organogenous material. Sediments more clayey in the upper part).

Frequency: Highest in the whole core, but very varying (1 - 25), average about 6.

Dominant component: Extant pollen, mainly aperturate types, and sporadically green-algae.

Among the extinct palynomorphs the Leio-group is dominant in the lower part of the subunit and extinct pollen in the upper part, where the dominance of aperturate extant pollen decreases on behalf of the pollen of coniferous trees.

Subunit 3:3 (68.5 - 59.2 m, coarse sediments).

Frequency: The content of palynomorphs extremely low (0.3). A few representatives of extinct groups noted (and one *Pediastrum* fragment) in the samples analysed.

Unit 4. (59.2 - 48.6, boulder clay with silt and sand).

Frequency: Quite low, average 1:3 in the four samples analysed.

Dominant components: Extinct groups (61%) of which pollen 22% (mainly aperturate types), Dino-Acri-group 18%, Leio-group 15% and extinct spores 6%. Extant groups compose 29% of the spectrum with dominance of pollen (21%), mainly coniferous types. Extant spores are present with 6% and green-algae with 1%.

Unit 5. (48.6 - 42.0 m, mainly silty sediments).

Frequency: Low (average 1) in the three samples analysed.

Dominant component: Extant pollen, 70%, both of coniferous types (40%) and aperturate pollen (30%).

Extant spores compose 7% and green-algae 4% of the spectrum.

Extinct groups together are present with 17%, mainly extinct aperturate pollen types (7%) and Dino/Acri-group (8%).

Unit 6. (42.0 - 31.50 m, silt, clay and boulderclay).

Frequency: Relatively high, average 2.5, in the five samples analysed.

Dominant component: Extant pollen, about 70%, mainly of coniferous trees and shrubs. Highest values of extant groups between and 36 - 34 m.

Unit 7. (31.5 - 4.0, mainly till).

Subunit 7:1 (31.5 - 21.7 m, till with interlying silt and clay).

Frequency: Quite low, average 1.3 in the five samples analysed.

Dominant component: Extinct groups compose 52% of the spectrum.

Pollen 21%, spores 9%, Dino/Acri 17% and Leio 5%. Extant groups compose 38%, with dominance of coniferous pollen types, 27%.

Subunit 7:2 (21.7 - 4.0 m, clayey till homogeneous).

Frequency: Very low, average 0.8 in the four samples analysed.

Dominant component: The extinct groups compose 51% of the spectrum. Dino-Acri-group 20%, Leio-group 16%, spores 9% and pollen 6%. The extant groups compose 38% of the spectrum, mainly extant pollen of coniferous trees (22%).

Stratigraphical remarks: According to the palynomorphic spectra 6 main types of strata can be distinguished, namely 2 different tills and 4 sediment types.

1. Sediments, coarser, 96.0 - 89.75 m (unit 3:1) directly overlying and as crack-filling in the Danian bedrock. Dino group and extinct pollen dominate. No extant palynomorphs have been noted.
2. Sediments, finer, 89.75 - 68.5 m (unit 3:2). - High content of extant pollen, sporadically also green-algae and spores.
3. Sediments, coarse, 68.5 - 59.2 m (unit 3:3). - Very poor in palynomorphs, mainly extinct types.
4. Till, heterogeneous, 59.2 - 48.6 m (unit 4), occurring as lumps and thinner, disturbed beds of boulder clay, mixed with silt and sand. - Extinct palynomorphs dominating, mainly Dino/Acri-group and aperturate pollen-types. Among extant pollen coniferous types dominate.
5. Sediments, finer 48.2 - 31.5 m (units 5 and 6), silt and clay with some occurrence of boulder clay. - Extant pollen dominate, mainly coniferous types.
6. Till, clayey, more homogeneous, 31.5 - 4.0 m (unit 7). - Extinct palynomorphs dominate. Extant pollen mainly represented by coniferous types.

2.3.2.2. Pollen and spores.

a) Total pollen and spore spectra of the whole core (Fig. 28 A, B)

The total content of pollen and spores noted in the Hyby-core and in the mixed samples between 88 and 73 m is presented in the diagram as Fig 28 A and B. (Note the different depth-scales used!) To make the correlation with the total palynomorphic spectra easier a somewhat simplified version of Fig 27 is included nearest to the column of lithology as the first part of the diagram. The diagram is divided into palynomorphic units 3 - 7.

The total pollen and spore diagram (the second part of the diagram) shows the relative frequency between the content of extant and extinct pollen and spores + *Varia* sporomorphs (or palynomorphs). In the field of extant pollen the percentage values of Pinus, Betula and Picea are shown (counted from the left).

The third part of the diagram illustrates the composition of the group of extinct pollen and the percentages of *Varia* and extinct spores. The group of extinct pollen is divided into vesiculate, inaperturate and aperturate types (according to page 37) The aperturate types are grouped after their primary stratigraphical distribution (mainly after Krutzsch 1957) in the pre-Quaternary (Tertiary and Cretaceous) bedrock.

The group of coniferous pollen, which includes vesiculate (Pinus haploxylon-type and other vesiculate types) and inaperturate pollen types, mainly originates from Upper Tertiary deposits (Miocene-Pliocene), but there also may be older Mesozoic types included to some extent.

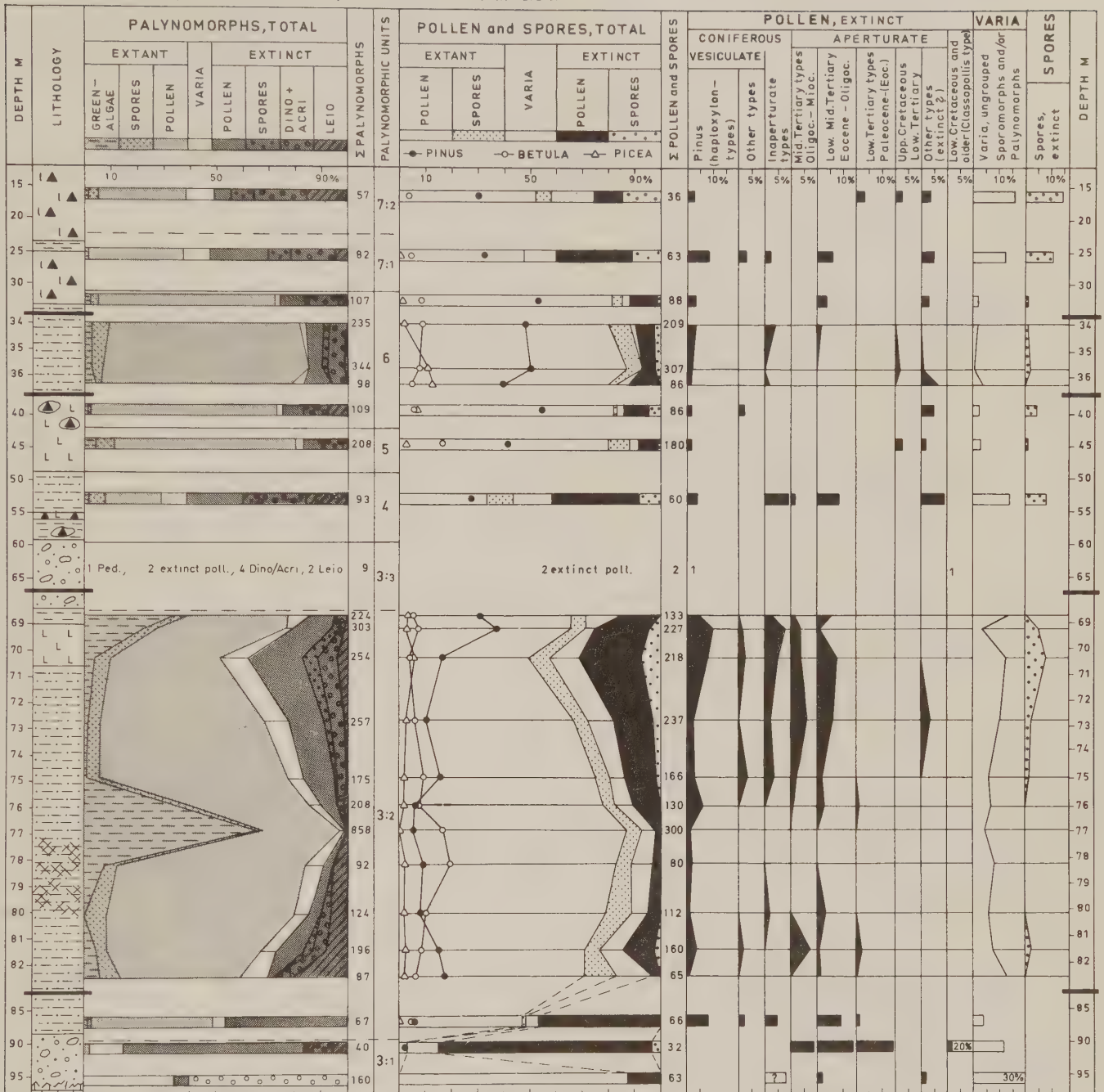
The group of *Varia* mainly is composed by unknown or badly preserved sporomorphs. It may also include some sporomorph-like palynomorphs of the Dino/Acri group.

The different stratigraphical palynomorphic units are characterized as follows: (Fig. 28 A, B)

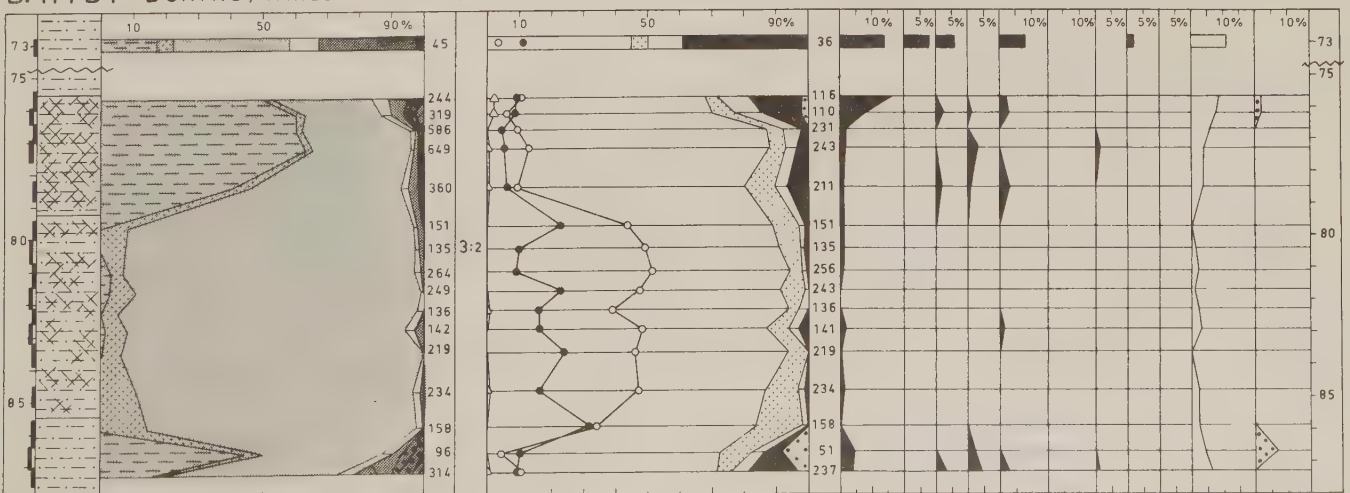
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Fig 28 A,B. Hyby-core.
Pollen and spore spectra in
A. Core samples, B. Mixed
samples.

A. HYBY CORE, ALNARP VALLEY, ALTITUDE 34.6 m a.s.l.



B. HYBY BORING, MIXED SAMPLES (72-88 m)



Unit 3 (96.0 - 59.2 m) sediments.

Subunit 3:1 (96.0 - 89.75 m, sand and gravel): Extant group almost absent. In the extinct group vesiculate types and spores absent. Inaperturate group represented in the lower spectrum by uncertain types, which probably may belong to the dominating *Varia* group, here difficult to distinguish from the *Dino/Acri* group. The few aperturate pollen grains noted in the lower spectrum differ from the types present in the upper spectrum. Lower Cretaceous and older *Classopollis*-types is dominant in the upper spectrum, together with Tertiary aperturate types, mainly of Lower Tertiary age. The only extant pollen grain noted is of *Pinus silvestris*-type.

Subunit 3:2 (89.75 - 68.5 m, mainly silt and fine sand): A comparison is made between the core samples (Fig 28 A) and the mixed samples (Fig. 28 B) of the same stratigraphical subunit. The palynomorphic spectra show that the content of extinct groups is considerably higher in the core samples than in the mixed samples between 80 and 83 m. The striking peak of green- algae at 78 - 70 m is registered in both of the sample series. The mixed samples from 75 m and upwards are very poor in microfossils. The preliminary results of the quantitative analyses made of these samples are not presented in the diagram except the very approximate spectrum at 73 m. The frequency of palynomorphs in the mixed samples series 75 - 86 m is considerably higher than in the corresponding core samples.

Concerning the total pollen and spore diagram the relation between extant and extinct groups is in quite good agreement. Some differences occur between the uppermost mixed sample (73 m) and corresponding core sample, caused probably by the extremely low basic sum of the mixed sample. The little peak of extinct pollen at 81.5 m (core sample) is not registered in the mixed samples at the corresponding level. The frequency of pollen and spores is about 5 times higher in the mixed samples than in the core samples.

The composition of the extant group is presented in Fig 29 A and B more in detail described on p 59). Here only will be mentioned the percentage values of the arboreal components, which are extremely low in the core samples (Fig 28 A), except in the two uppermost samples, where *Pinus* dominates. In the diagram of mixed samples (Fig 28 B) the percentages of *Betula* and *Pinus* are strikingly higher.

The group of extinct pollen is mainly represented by coniferous types, vesiculate as well as inaperturate ones. *Pinus haploxylon*-type is dominant. The aperturate group is mainly composed by pollen types of Lower to Middle Tertiary origin. Paleocene and Upper Cretaceous types are very sparsely represented. Lower Cretaceous and older types are absent. The occurrence of extinct spores and *Varia* approximately follows the occurrence of extinct pollen.

Subunit 3:3 (68.5 - 59.2 m, coarse sediments). Pollen and spores almost absent. Only two extinct pollen grains (*Pinus haploxylon*-type and *Classopollis*-type) noted.

Unit 4 (59.2 - 48.6 m, boulder clay with spores fine-grained sediments). The extant and extinct groups of pollen and spores represented with almost equal percentages (43% and 42%). In the extant group Pinus dominantes (28%). Betula and Picea not noted. Extant spores present (10%), (Polypodiaceae and Sphagnum/ Extinct pollen mainly aperturate types of Lower-Middle Tertiary age (Eocene). Middle Tertiary types sparsely represented. Lower Tertiary, Upper Cretaceous and older types absent. Coniferous extinct types mainly represented by inaperturate types. Pinus haploxylon type occurs sparsely (4%). Extinct spores present (10%), mainly Gleichenidites-type.

Unit 5 (48.6 - 42.0 m, mainly fine-grained sediments). Extant group dominates greatly (88%). Dominance of Pinus (40%). Betula present (15%), Picea noted (3%). Extant spores (8%) represented mainly by Sphagnum. Extinct group sparsely represented by mainly aperturate pollen (5%) of which some identified as Upper Cretaceous types. Only coniferous type to occur - Pinus haploxylon (2%).

Unit 6 (42.0 - 31.5 m, mainly fine-grained sediments, mixed with some boulder clay in the upper and lower parts). Extant group dominates. Pinus (40 - 55%). A little peak of Picea at 3 m (12%). Extant spores represented by Polypodiaceae and Sphagnum.

Extinct group sparsely represented (7 - 14%). Vesiculate and inaperturate types present. Aperturate pollen of Upper Cretaceous and Lower-Middle Tertiary age. Extinct spores rare, except at 40 m, where they compose about 5% of the spectrum (mainly Gleicheniidites-type

Unit 7 (31.5 - 4.5 m)

Subunit 7:1 (31.5 - 21.7 m, till with interlying fine-grained sediments). Extant group represented by pollen only (47%). Dominance of Pinus (32%). Betula and Picea noted sparsely. Extant group compose 40%, mainly coniferous pollen types with dominance of Pinus haploxylon-type. Aperturate pollen mainly of Lower-Middle Tertiary age. Extinct spores are common (11%).

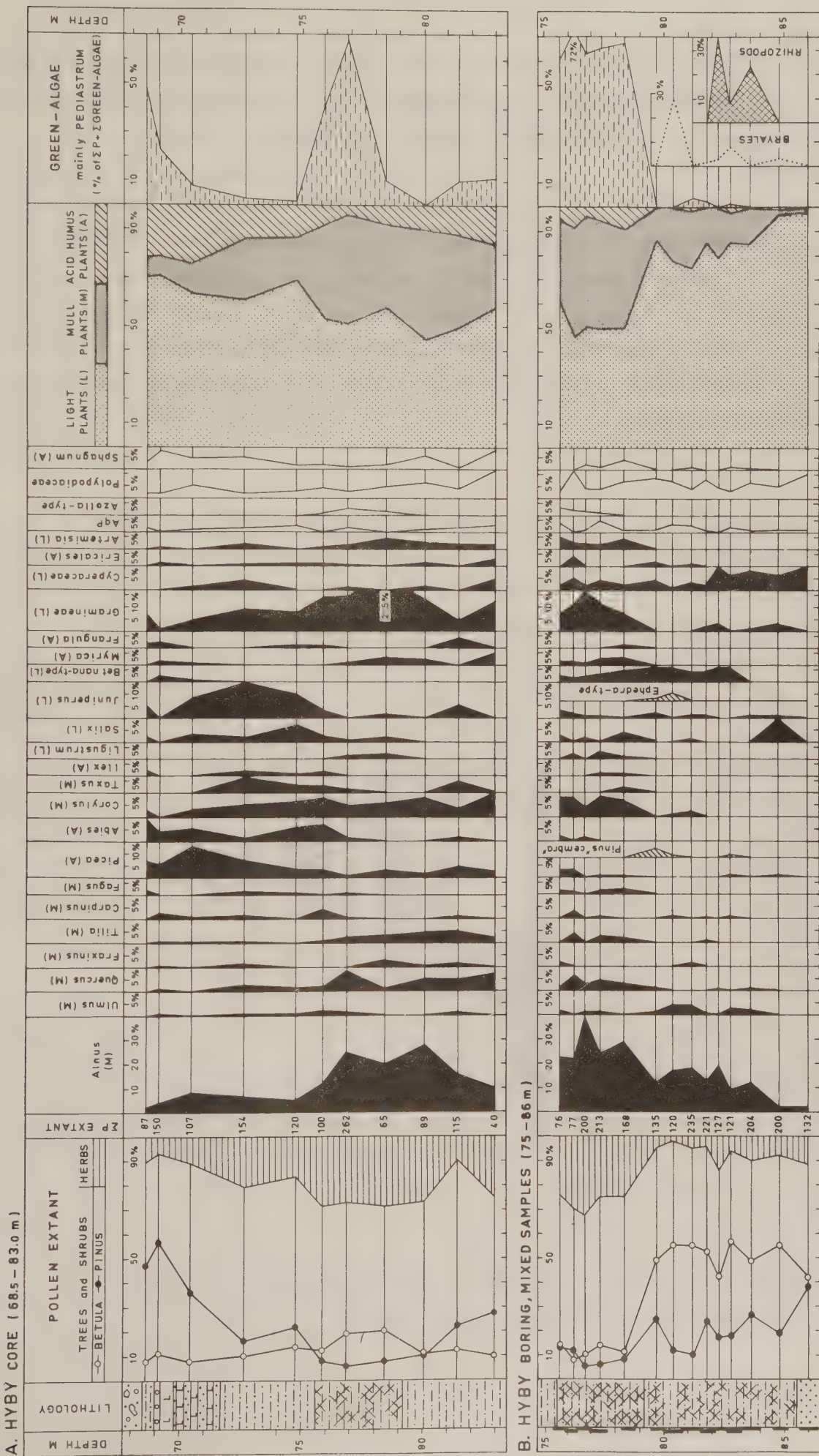
Subunit 7:2 (21.7 - 4.0 m, mainly till). Extremely poor in pollen and spores. Extant group composes 58% of the spectrum. Pinus dominantes with 30%. Betula sparsely represented. Picea absent. A few extant spores noted. Extinct group compose 31% of the spectrum, mainly extinct spores (Gleicheniidites-type and others). Extinct pollen represented by aperturate types of Lower Tertiary and Upper Cretaceous age. Pinus haploxylon-type sparsely noted.

b) The extant pollen spectra of the fine-grained sediments 68.5 - 86.0 m (paleo-nomorph unit 3:2). The extant pollen spectra of the Hyby boring 68.5 - 83.0 m are presented in Fig 29. Part A represents core samples and part B mixed samples. The diagrams show from the left:

1. Depth below the surface level and lithology of the sequence.
2. Total relation diagram of pollen, grouped as: pollen of trees and shrubs pollen of herbs. In the field of arboreal pollen the percentage curves of Pinus and Betula are drawn (both counted from the left).
3. The number of pollen grains counted ($P_{\text{extant}} = 100\%$).
4. Silhouette curves of the components of ΣP , i.e. trees shrubs and main components of herbaceous pollen.
5. Pollen of aquatic plants (AqP), massulae of Azolla-type, spores of Polypodiaceae and Sphagnum. These components are calculated as percentages of ΣP .
6. Comparative relation diagram of the components, grouped as light-plants, mull plants and acid humus plants (after Andersen 1969).
7. Curves of green-algae (mainly of genus Pediastrum) and other groups of extant palynomorphs noted: Bryales spores and rhizopods, calculated as percentages of $\Sigma P + \Sigma$ of the palynomorph group concerned.

In the core-section the frequency of extant pollen is very low in the lower part 83 - 78 m and in the upper part at 72 - 70 m, corresponding to 0.5 - 2 pollen grains noted per transverse. In the middle part (77 - 73 m) and in the uppermost part (69.2 - 68.5 m) the frequency is somewhat higher, 2 - 6.5 pollen grains/transverse. In the mixed sample series the frequency of extant pollen is considerably higher, varying between 2 and 65, in general 10 - 30 pollen grains per transverse.

The diagrams of both sample series are almost equivalent between 76 and 78 m, i.e. the upper part of the mixed samples preliminary analysed, is very poor in pollen. This part of the fine-grained sediments is better represented by the core samples. From 78 m downwards both sample series overlap each other, but the diagrams are not equivalent nor comparable. The core samples between 78 and 83 m have very low pollen frequency. In this sequence the main part of the core was lost. The core samples here represent the very compacted minerogenous part of the sediments, which can not be considered as representative for the sequence. The mixed samples on the contrary have high frequency of extant pollen between 78 and 86 m and probably reflect the pollen spectra of the sediments in a more reliable way.



Below 86 m the mixed samples as well as core samples have an increasing admixture of extinct pollen and the pollen frequency is low. For that reason these samples have been only preliminarily analysed and are not included in the diagrams presented.

Taking into account the circumstances mentioned above, the most reliable pollen spectra of both pollen diagrams are those of the core samples between 68.6 and 77 m and those of the mixed samples between 76 and 86 m. Combining these parts of the two diagrams a more likely development of the vegetation more or less contemporary with the lacustrine and drift sediments between 68.5 and 86 m will be obtained (Fig 30).

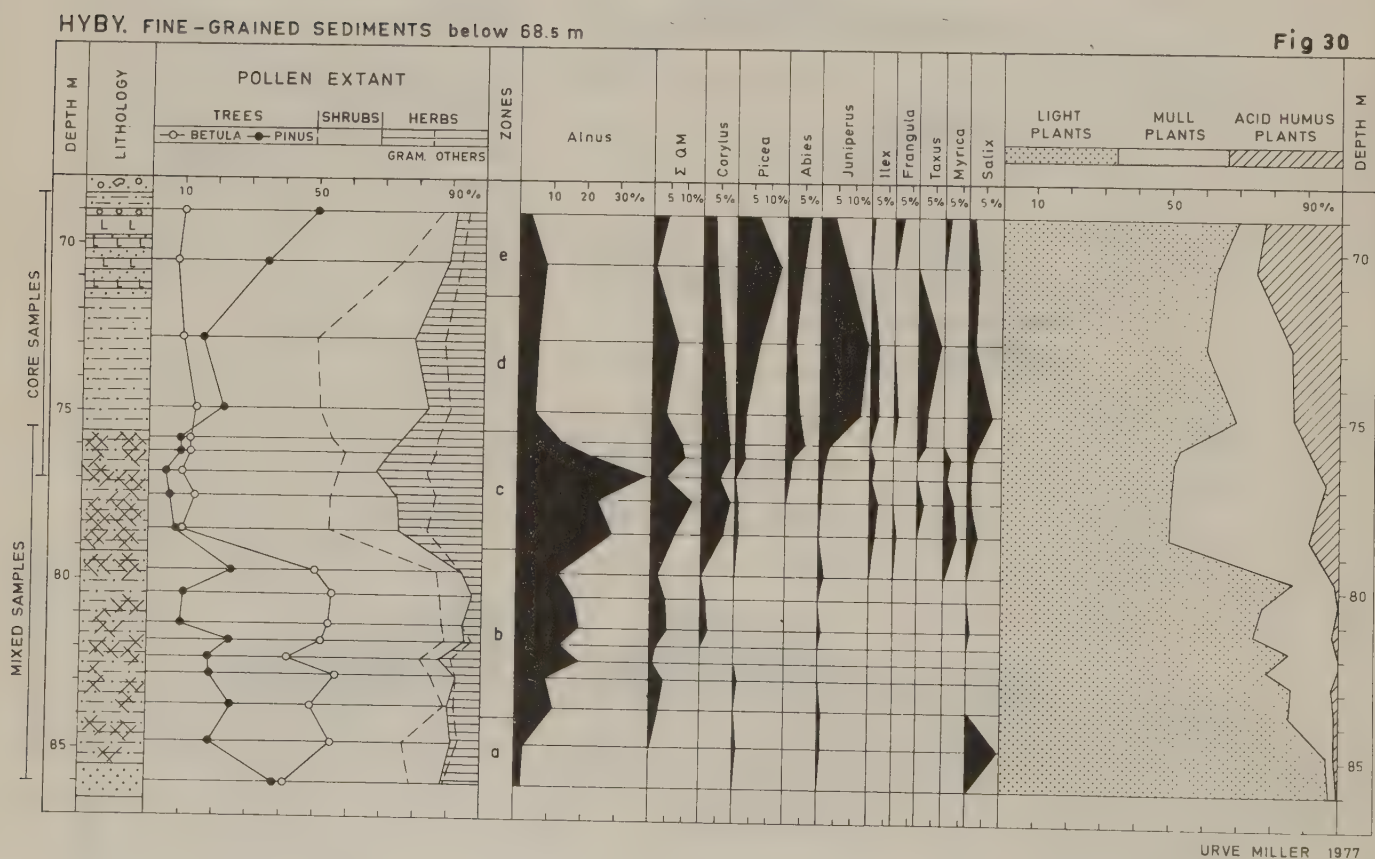


Fig 30. Hyby. Extant pollen diagram of the fine-grained sediments below 68.5 m. Combined core samples and mixed samples.

The pollen diagram is divided into five pollen assemblage zones a - e after the composition of the extant pollen spectra, as follows (Fig 30):

Zone a (86 - 84 m) Betula-Pinus pollen zone.

Betula dominates. Pinus common. Alnus occurs sparsely. Shrubs represented by Salix. Herbs occur with about 10%. Light plants compose more than 95% of the pollen spectra.

Zone b (84 - 79 m) Betula-Pinus-Alnus pollen zone. Betula dominates. Pinus and Alnus common. Shrubs and herbs have low values. Light plants dominate (75 - 85%). Mull plants compose most of the remaining 15 - 25%. Acid humus plants occur very sparsely.

Zone c (79 - 75.5 m) Alnus-QM-Corylus-herbaceous pollen zone. Alnus dominates. QM and Corylus occur with their highest values. Shrubs and herbs together compose more than 40% of the pollen spectra. Herbaceous pollen have maximum (25 - 32%). Shrubs as Ilex, Frangula, Taxus and Myrica have here their first appearance, as well as Abies. Light-plants have decreased to 50%. Mull plants compose 40 - 45% and acid humus plants are represented with 4 - 9%.

Zone d (75.5 - 71.5 m) Shrub-herb Pinus pollen zone. Shrubs as Juniperus, Taxus, Salix, Ilex, Corylus and Frangula compose about 30% of the pollen spectra. Alnus has decreased to 5%. Betula occurs with low values. Pinus has a slight increase. Picea and Abies are present with low values. Herbs compose about 20% of the pollen spectra. Light plants increase again to 60 - 70%. Mull plants occur with 20 - 25% and acid humus plants increase to 15%.

Zone e (71.5 - 68.5 m) Pinus-Picea zone. Pinus dominates. Picea has a maximum with 13%. Abies occurs with 5 - 7%. Betula and Alnus continue with low values. Shrubs and herbs decrease. Myrica and Frangula represented with low values. Light-plants compose up to 70% of the pollen spectra. Mull plants decrease to about 10%. Acid humus plants have in this zone their maximum values up to 25%. The composition of the pollen spectra and the characteristic succession of plants in the pollen assemblages zones indicate interglacial conditions at the sedimentation. The pollen zones distinguished seem to represent vegetational development from a proto-cratic (Iversen 1958, Andersen 1969) phase (zones a and b) with transition to a weakly developed mesocratic phase (zone c) with deforestation, which continues

during the oligocratic phase (zone d). The uppermost pollen spectra reflect the beginning of a telocratic phase (zone e). This type of vegetational development has most similarity with the conditions characteristic to the Holsteinian interglacial stage (Andersen 1963, 1964, 1965b, 1966, West 1968) An alternative interpretation would be the Eemian stage, but the low values of Corylus, QM, and Picea, the occurrence of Fagus, Frangula and Azolla massulae, contradict this possibility. If the sediments are of Holsteinian age, this interglacial is registered for the first time in Sweden.

c) The extant pollen spectra of the fine-grained sediments 31.5 - 48.6 m (paleomorph units 6 and 5) are presented in Fig 31.

The spectra show quite similar pollen composition through the whole sediment sequence. Tree pollen with great dominance of Pinus compose 80 - 85% of the spectra. Betula occurs with highest values (20%) in the lowermost spectrum, decreasing upwards to 5 - 10 %. Alnus is sparsely represented (4 - 6%) and disappears in the uppermost spectrum. QM and Corylus are present in all the spectra, but with quite low values. Picea has a pronounced maximum at 36.5 - 35.5 m (13 - 16%). Shrubs and herbs occur with quite low values mainly represented by Juniperus, Salix, and Gramineae. Ilex and Ericales (Empetrum) pollen grains are noted at 35.5 m. Spores of Polypodiaceae and Sphagnum are present in all the samples, except at 39 m. Colonies of green-algae, mainly Pediastrum are noted in all the samples, but with low frequencies.

A division of the pollen spectra into light, mull and acid humus plants show that the light plants dominate. Mull plants are sparsely represented. Acid humus plants occur with maximum values (16 - 19%) at 35.5 - 36.6 m (Picea maximum).

The pollen, probably more or less redeposited, contain elements of an interglacial vegetation. Typical interstadial or early interglacial (late glacial) components are not present. The dominance of light plants and the low values of Betula and Alnus, together with the presence of QM (Tilia and Quercus) and Corylus indicate an origin from a later phase of an interglacial. The relatively high values of Picea speak in favor of the Eemian interglacial but the indications are too weak and the analyses too preliminary, for any interpretations to be made.

HYBY. FINE-GRAINED SEDIMENTS (31.5–48.5 m) CORE SAMPLES

Fig 31

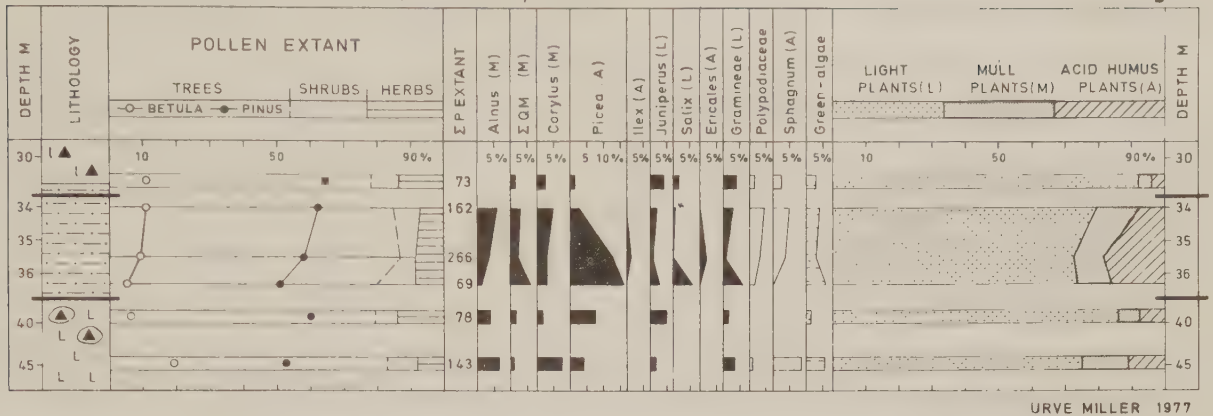


Fig 31. Hyby-core. Extant pollen spectra of the fine-grained sediments 31.5 - 48.5 m.

2.2.2.3 Siliceous microfossils, concerning mainly Pleistocene diatoms.

The alphabetic list of siliceous microfossils found in the Hyby-core with their frequency and distribution in the different strata is presented in Table 2. It comprises about 60 Pleistocene and 80 Lower Tertiary diatom taxa + 12 silicoflagellate taxa. The division of the Hyby-core into different diatom units, mainly based on the reworked pre-Quaternary siliceous microfossil content, has been described on page 50. Here the occurrence and character of the Pleistocene diatoms in the Hyby-core samples (Table 2) and in the mixed samples of the fine-grained sediments below 71.6 m (Table 3) will be discussed.

Pleistocene diatoms occur in the Hyby-core samples as follows:

- Sediments below 71.6 m (diatom units 3a and 3+1). Pleistocene diatoms noted are mainly alkaliphilous fresh water species with presence of so-called clear-water forms in the lower part 96.16-95.50 m) listed in Table 6.
- Sediments and boulder clay 59.2 - 55.0 m (diatom unit 4a). Pleistocene diatoms quite abundant, mainly acidophilous and indifferent (to pH) species, listed in Table 4.

c) Sediments, mainly clay 48.6 - 42.0 m (diatom unit 5). Pleistocene diatoms occur very sparsely, but all the species noted are marine or brackish. The species identified are:

Chaetoceros holsaticus (resting spores)

Hyalodiscus cf scoticus (fragments)

Melosira sulcata

Campylodiscus clypeus (fragments)

Rhabdonema arcuatum

Rhabdonema minutum v. sulcatum

The marine Pleistocene diatoms in the clay between 42.8 and 48.6 m may be interpreted as originating from redeposited marine interglacial sediments of the Holsteinian or Eemian age (cf page 64, extant pollen spectra of interglacial origin, Fig. 31).

The presence of acidophilous Pleistocene diatoms (Tab 4) in the silty-sandy sediments mixed with boulder clay (59-55 m), containing abundant pre-Quaternary siliceous microfossils (listed in Tab 5) is remarkable. The stratum overlies the sequence of coarse sediments (68.5 - 59 m), which mainly consist of crushed limestone (Cretaceous) deposited in connection with a glacial stage. The palynomorphic spectra of the sediments mixed with boulder clay show high content of extinct palynomorphs (Fig 26), palynomorphic unit 4), indicating glacial conditions. The extant pollen group is mainly composed of coniferous pollen (Pinus silvestris-type) as it appears in Fig 27. The following two explanations may be suggested:

- 1) The diatom flora originates from an interstadial phase (or oscillation) with almost arctic climate and no leaching of mineral salts from the sediments. No elements of tundra vegetation are registered in the pollen spectra. The climate must have been too rigid for any type of vegetation to develop. The acidophilous diatoms are in this case more or less contemporary with the oscillation phase.
- 2) The acidophilous diatom flora is redeposited from sediments originating from the end phase of previous interglacial and registers increased acidification (paludification during the telocratic phase). The dominance of Pinus pollen in the extant group speaks in favor of this explanation.

The Pleistocene lacustrine (alkaliphilous to circum-neutral) fresh-water flora in the fine-grained sediments between 96 and 71.6 m contains, in the lower part of the sediments species belonging to the clear-water flora. They indicate a sedimentation milieu corresponding to the conditions in the end of a glacial (late-glacial) or the beginning of an interglacial stage, i.e. transparent water rich in mineral salts. (Tabel 6). In core samples the diatom content upwards in the sediments is very low. The mixed samples have a relatively much higher content of Pleistocene diatoms. In Tabel 3 an alphabetic list of diatoms noted in the mixed samples, composing about 60 Pleistocene fresh-water and 25 pre-Quaternary marine taxa. Fig 32 shows the total composition of the siliceous microfossil spectra in the mixed samples. The dominating components are Pleistocene centric, planktic diatoms (with Cyclotella comta et v. radiosa as dominant species) and transformed siliceous microfossils originating from the Danian bedrock. The exceptions are: 1) the mixed sample 81.45 - 82.05 m, where the Lower Tertiary diatom flora dominates; 2) the mixed sample 78.2 - 78.8 m with absence of Pleistocene centric diatoms. The species which occur are pennate epiphytic and benthic forms; 3) the mixed samples at 77 m where the content of pennate Pleistocene diatoms corresponds approximately to the content of centric diatoms.

The typical clear-water species disappear in connection with the increasing content of gyttja in the sediments between 85 and 80 m (Fig 30, pollen zone b). Between 80 and 76 m the frequency of Pleistocene diatoms in the sediments is very varyable and the number of benthic forms increases, reflecting changes in water-depth and other hydrological conditions. The uppermost mixed sample containing Pleistocene diatoms is 75.9 - 75.4 with Cyclotella comta v. radiosa again as dominating species. The overlying sediments are very poor in all kinds of siliceous microfossils. Almost the only group noted is the transformed. The sedimentation conditions must have been changed markedly in the beginning of pollen zone d (cf p 6 Fig. 30). The silty sediments upwards from 75 m contain no gyttja. From 71.5 m and upwards the sediments contain microstratified clay layers alternating with silty-sandy layers.

According to the diatom flora the interglacial lake at Hyby was of greater type with slightly alkaline to circum-neutral water. Comparable with the interglacial lakes in Denmark and Northern Germany, which abundant planktic fresh-water diatom floras produced the interglacial diatomite layers at Vejlbj, Hollerup and Oberohe etc (Foged 1954, 1960, 1962, Hustedt 1948, 1954.)

HYBY: SILICEOUS MICROFOSSILS

MIXED SAMPLES. 71.60 - 96.56 m

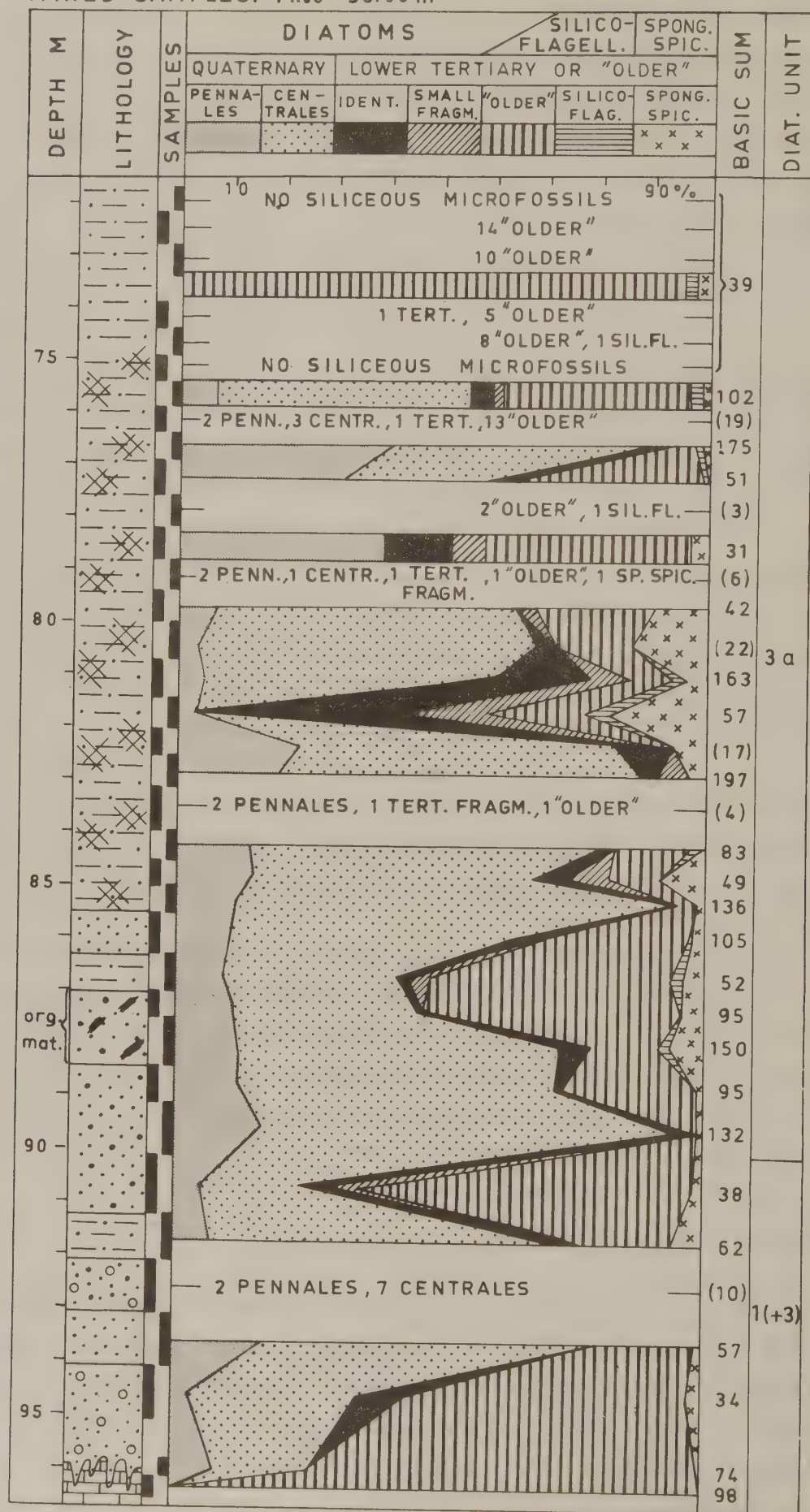


Fig 32. Hyby. Relation diagram of the different groups of siliceous microfossils in the fine-grained sediments between 96 and 71.6 m. Mixed sample.

2.3.3. GÄRDSLÖV-core. The description of the Gärdslov-core contains:

	page
2.3.3.1. Total spectra of siliceous microfossils and of palynomorphs (Fig 33) ..	70
2.3.3.2 Pollen and spores	75
a) total pollen and spore spectra (Fig. 34)	
b) extant pollen spectra of the fine-grained sediments below 80 m (units A:3 and A:2, Fig 35,36)	
c) extant pollen spectra of the fine-grained sediments and of the uppermost till sample 6.1 m - 2.0 m (unit E, Fig 37)	
2.3.3.3. Siliceous microfossils	83
a) in the whole core	
b) the Pleistocene (Late Weichselian) diatom flora of the fine-grained sediments 5.7 - 3.6 m (unit E, Fig 38).	

The detailed sequences of strata in the Gärdslov-core are shown in the total microfossil diagram, column of stratigraphy (Fig 33). A generalized description of the stratigraphy is presented on page 31. The core-material has been analysed for its content of siliceous microfossils and palynomorphs to distinguish the main stratigraphical units with regard to their microfossil spectra.

The frequency of siliceous microfossils in the Gärdslov-core is low compared with the Tofthög and Hyby-cores. The exception is the uppermost part of the core, where Pleistocene fresh water diatoms occur abundantly in the sediments 5.7 - 3.6 m and the reworked Lower Tertiary Eocene marine diatom flora is present more frequently in the uppermost part of the upper till bed (12.5 - 5.7 m). This part of the core is presented as a special diagram (Fig 38) and will be closer discussed on page 83. An alphabetic list of the siliceous microfossils noted in the Gärdslov-core, with their distribution and frequency in the different stratigraphical units is compiled in Table 7. The list comprises about 75 Pleistocene fresh-water taxa and 45 pre-Quaternary marine taxa.

The frequency of palynomorphs in general is somewhat higher in the Gärdslov-core than in the Hyby-core, except in the upper till bed between 45 - 12.5 m, where the content of palynomorphs is extremely low. The total pollen spectra and the distribution of the main types of extinct pollen and spores is shown as a separate diagram in Fig 34. The parts of the core, where the group of extant pollen dominates, i.e. parts of the fine-grained sediments below 80 m (80 - 99 m) and uppermost sediment strata (2 - 5 m) are presented as separate diagrams (Figs 35, 36 and 37).

Fig 33. Gärdslov-core.
Total spectra of siliceous
microfossils and palynomorphs



2-3.3.1. Total spectra of siliceous microfossils and palynomorphs

The microfossil spectra of the Gärdslov-core differ from those of Tofthög and Hyby-cores by showing a more uniform character. The system of stratigraphical division used for the Hyby and Tofthög-cores is not directly applicable to the Gärdslovs-core. For that reason the division of the Gärdslov-core into different stratigraphical units according to the diatom and palynomorphic spectra, is made for the two microfossil groups together, independent of the division of the other cores. The Gärdslov-core is divided into 5 main stratigraphical units, called A-E.

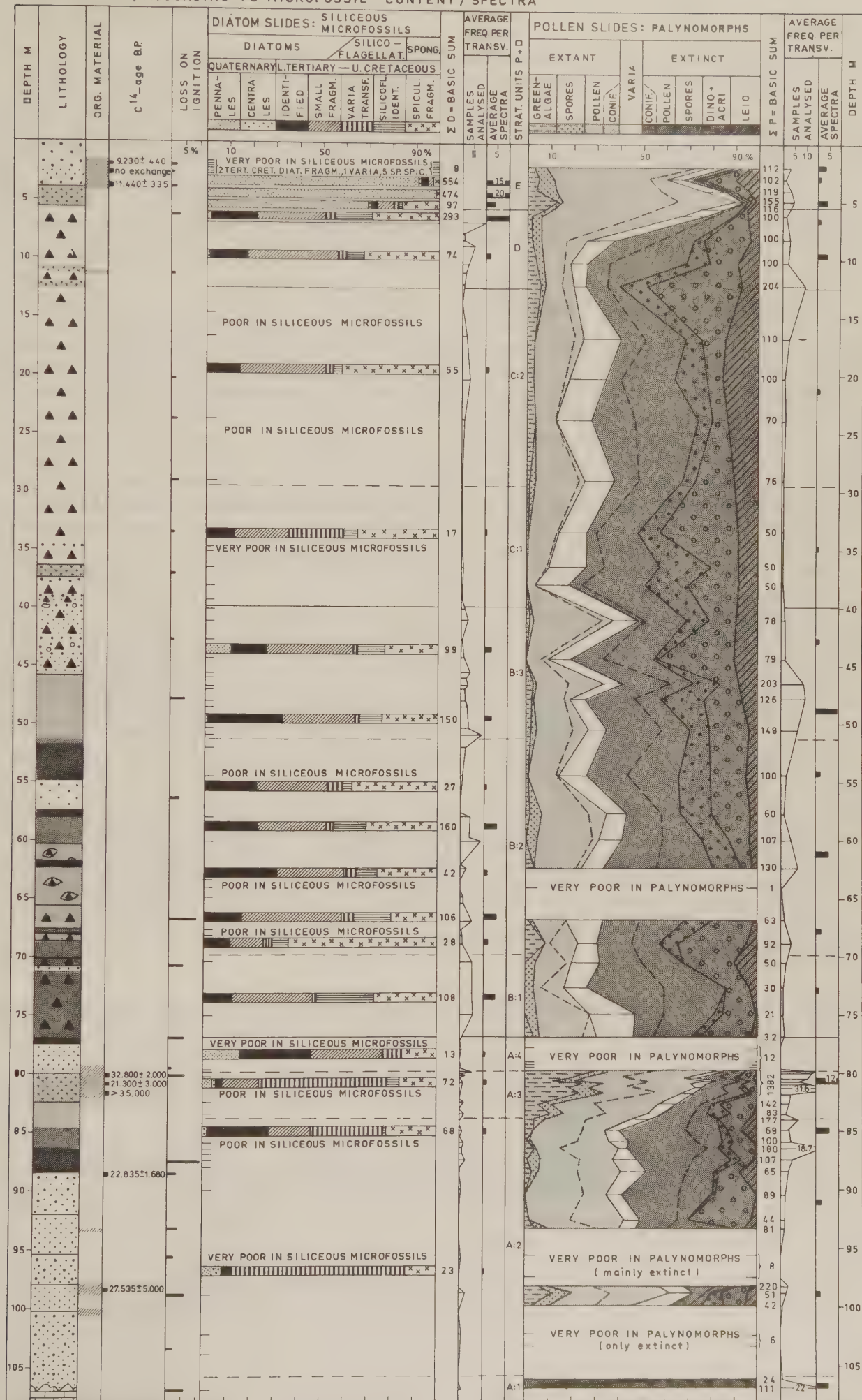
Unit A is divided into 4 subunits A: 1-4

Unit B is divided into 2 subunits B: 1-2

Unit C is divided into 2 subunits C: 1-2

Units D and E are not divided into subunits.

GÄRDSLÖV CORE, ALNARP VALLEY, ALTITUDE 45.8 m a.s.l.
STRATIGRAPHY, ACCORDING TO MICROFOSSIL CONTENT / SPECTRA



Unit A (107 - 77 m, fine-grained sediments).

Diatom spectra: Approx. 25 samples analysed. Frequency of siliceous microfossils very low (average 1 per transverse). Main components are the groups of transformed frustules and Lower Tertiary marine diatoms. Silicoflagellates almost absent. Sponge spicules present, but not dominant. A few representatives for Pleistocene fresh-water diatoms noted, mainly alkaliphilous species. Melosira arenaria, Melosira islandica, Cymatopleura solea, Navicula mutica, some of them clear-water forms.

Palynomorphic spectra: Divided into subunits A:1 - A:4.

Subunit A:1 (107 - 106 m, fine sand as crack-filling in the underlying bedrock. Two samples analysed. Frequency high in the lower, markedly decreasing in the upper sample. The spectra are composed by Dino/Acro-group originating from the underlying Danian bedrock and a few extinct spores and pollen. No extant palynomorphs noted.

Subunit A:2 (106 - 84.1 m, fine grained sediments with no or diffuse stratification some sporadical admixture of organogenous material). 15 samples analysed. Lower part (106 - 100.5) very poor in palynomorphs, only some extinct types noted. In the silty fine sand stratum between 100 and 98 m, the content of palynomorphs quite high, with dominance of extant pollen, coniferous as well other types (Special diagram, Fig 35). All extinct groups are present, composing together 30 - 35% of the spectra. The sandy-silty sediments between 98 and 93.5 m are very poor in palynomorphs. The noted types belong mainly to the extinct groups. From 93.5 m and upwards the frequency of the palynomorphs increases in the sediments. Extinct groups dominate composing 50 - 60% of the spectra. Main component is the group of extinct pollen with dominance of coniferous types. Extant groups represented with about 40%, mainly pollen of coniferous and other types. Sporadically also Dino/Acri- and Leio-groups quite common.

Subunit A:3 (84.1 - 79.9 m, fine-grained sediments, mainly stratified clay and silt with thin layers of organogenous material. 10 samples analysed. Frequency of palynomorphs increasing upwards to 10 - 30 per transverse. Extant groups dominate (45 - 80%) with increasing values upwards. Main components: extant pollen, with slight dominance of coniferous types, and green-algae. The extinct groups decrease to 20 - 15% in the uppermost spectra (Special diagram, Fig 35).

Subunit A:4 (79.9 - 77.0 m, silty fine sand). 4 Samples analysed. Extremely poor in palynomorphs. Only a few types of extinct and extant pollen and 2 of Dino/Acri-group noted.

Unit B (77.0 - 40 m, mainly boulder clay 77.0 - 65.6 m, mainly fine grained sediments 65.6 - 45.8 - 40 m).

Lithologically of very heterogenous composition. Distinguished from the upper till (unit C) because of higher frequency of microfossils.

Subunit B:1 (77 - 70 m, boulder clay).

Diatom spectra: 2 samples analysed. Frequency of siliceous microfossils about 5 per transverse. Main component is the group of Lower Tertiary diatoms, main-

ly present as small fragments. Silicoflagellates and sponge spicules are common. The transformed frustules are almost absent. No Pleistocene diatoms have been noted.

Palynomorphic spectra: 4 samples analysed. Poor in palynomorphs, average frequency about 1 per transverse. Dominance of extinct groups (55 - 75%), mainly extinct pollen (30 - 60%) and Dino/Acri-group (10 - 20%).

Subunit B:2 (70.0 - 51.5 m, boulder clay, alternating with stratified clay, sand layer at 57.5 - 55 m, clay 55 - 51.5 m).

Diatom spectra: 16 samples analysed. Frequency low, varying between 0.5 - 5 per transverse. Main component is the group of Lower Tertiary diatoms, composing 50 - 60% of the spectra, except in the lowermost spectrum of the subunit, where sponge spicules are highly dominant. Silicoflagellates and transformed frustules present in all the spectra. No Pleistocene diatoms noted.

Palynomorphic spectra: 7 samples analysed. Frequency varying, in averages some higher than in subunit B:1. Extinct groups dominate highly (60 - 70%). Extinct pollen compose 25 - 45%, extinct spores 10 - 15%. Dino/Acri-group 10 - 30%. Leio-group sparsely represented. Extant groups occur with 15 - 35%, mainly pollen of aperturate types.

Subunit B:3 (51.5 - 40 m, clay 51.5 - 45.8 m, till 45.8 - 40 m).

Diatom spectra: 12 samples analysed. Frequency about 3 per transverse. Lower Tertiary diatoms dominate (50 - 60%). Silicoflagellates compose 10 - 15% and sponge spicules 20 - 25% of the spectra. Transformed frustules almost absent. A few fragments of Pleistocene fresh water diatoms noted (of pennate genera Amphora, Epithemia, Fragilaria, Nitzschia and Synedra).

Palynomorphic spectra: 5 samples analysed. Frequency in the clay samples markedly high, about 10, in the till samples low, about 2 per transverse. The composition of the spectra variable. Extinct groups dominate with 50 - 75%. Extinct pollen and spores are main components in the clay samples. In the till samples Dino/Acri-group has a maximum (30%). Leio-group increases slightly upwards. The group of extant pollen occurs with varying values (10 - 30%), mainly represented by aperturate pollen types.

Unit C (40 - 12.5 m, clayey till) is characterized by very low frequency of microfossils.

Subunit C:1 (40 - 29.5 m, till, heterogenous, with interlaying sand layers)

Diatom spectra: 6 samples analysed. Content of siliceous microfossils extremely low. All groups, except Pleistocene diatoms noted. Main components: Lower Tertiary diatoms, sponge spicules and transformed frustules.

Palynomorphic spectra: 3 samples analysed. Frequency very low. Extinct groups have a great dominance (75 - 80%). Extinct pollen, mainly aperturate types, and extinct spores dominate in the lower part. Peak of Dino/Acri-group (30%) Leio-group almost constant, about 10%.

Subunit C:2 (29.5 - 12.5 m, till, clayey-gravelly, homogeneous).

Diatom spectra: 5 samples analysed. Frequency low. Main groups are Lower Tertiary diatoms and sponge spicules, both very fragmented. No Pleistocene diatoms noted.

Palynomorphic spectra: 4 samples analysed. Frequency low. Extinct groups dominate (60 - 70%). Mainly extinct pollen of aperturate types (30 - 45%) and Leio-group (15%). Extant groups sparsely represented (15 - 25%) by extant aperturate pollen types.

Unit D (12.5 - 5.7 m, till, clayey-gravelly, with thin layers of silt in the lower part, very dark in the upper part, 6.2 - 5.7 m).

Diatom spectra: 10 samples analysed. Frequency increasing upwards to about 10 per transverse. Composition of spectra similar to subunit C:2. with dominance of Lower Tertiary diatoms and sponge spicules. Silicoflagellate are more common upwards. A few fragments of pennate Pleistocene diatoms noted.

Palynomorphic spectra: 4 samples analysed. Frequency 2 - 3, except in the lowermost sample (about 10). In the three lower spectra dominate extinct groups. Marked peak of Dino/Acri-group (40%) in the lowermost spectrum and dominance of extinct pollen types in the others. In the uppermost spectrum of the unit extant groups, mainly pollen of aperturate type, dominate (75%). The extinct groups together compose about 20% of the spectrum.

Unit E (5.7 - 0 m, sediments, with sporadical occurrence of organogenous material. Silty clay in the lower part, 5.7 - 3.9 m, sand in the upper part, 3.9 - 0 m).

Diatom spectra: 18 samples analysed. Frequency quite high in the lower part (5.7 - 3.6 m). In the upper part (3.6 - 1.5 m) extremely low. In the lower part Pleistocene pennate fresh water diatoms compose 70-100% of the spectra (special diagram, Fig 38). In the upper part no Pleistocene diatoms noted, only some fragments of pre-Quaternary siliceous microfossils.

Palynomorphic spectra: 5 samples analysed. Average frequency about 3 per transverse. Dominance of extant groups 60 - 90%. Mainly extant aperturate pollen types (special diagram, Fig 37). Green-algae group has a little peak at 5 m in the extinct group dominate Dino/Acri and Leio-groups (10 - 40%) with highest values at 3 m.

Stratigraphical remarks: According to the microfossil spectra the till types in the Gärdslov-core are not so clearly distinguishable as those of the Hyby- and Toft-hög-cores. The till bed at 77 - 70 m (subunit B:1) and at 45.8 - 40 m (subunit B 3) have almost the same composition of diatom spectra, characterized by dominance of fragmented Lower Tertiary diatoms and almost absence of transformed frustules. The strata between these till beds have some higher content of identifiable (less fragmented) Lower Tertiary diatoms. Transformed frustules are present, but with low values.

Concerning the palynomorphic spectra the extinct groups dominate. Pollen types and dinoflagellates present are mainly of Lower-Middle Tertiary (Eocene) origin (Fig 34).

The till bed between 40 and 30 m is very poor in microfossils, but the siliceous microfossil spectra as well as that of the palynomorphic show a clear change in composition, with admixture of Danian and older material.

In the uppermost part of the upper till bed at 12 m, a marked peak of Dino/Acri-group, mainly composed by Lower-Middle Tertiary dinoflagellates (according to Kjellström) and markedly increasing frequency of siliceous microfossils, mainly diatoms of Lower Tertiary age, indicate an admixture of material of Baltic origin.

Extant microfossils dominate only in some parts of the fine grained sediments below 80 m and upon the uppermost till bed 5.7 - 2 m (extant pollen types dominate also in the uppermost part of the till 6.3 - 5.7 m, which probably represents the first Late Weichselian paleosol).

2.3:3:2 Pollen and spores

a) Total pollen and spore spectra

The total content of pollen and spores noted in the Gärdslov-core is presented in the diagram Fig 34. The grouping and construction of the diagram mainly follows the same principales as used in Fig 28 (Hyby-core). The first part of the diagram shows the relation between the content of extant and extinct pollen + Varia. The second part illustrates the composition of the different groups of extinct pollen and the percentages of Varia and extinct spores. Moreover, the percentages of Dino/Acri-, Leio- and green-algae, are presented to the right in the diagram to show their frequency in relation to the composition of pollen and spore spectra.

The diagram is divided into stratigraphical units according to Fig 33 and characterized by the pollen and spore spectra as follows:

Unit A (107 - 77 m, fine-grained sediments).

Subunit A:1 (107 - 100.5 m). Very poor in pollen and spores. A few extinct spores, pollen and Varia noted, with dominance of extinct spores. Extant group absent.

Subunit A:2 (100.5 - 84.1 m). Frequency very varying. Dominance of extant pollen in the lowermost spectrum (98 - 100 m), at 88.5 and 87 m, alternately interrupted by admixture of extinct pollen. Spores, extant as well as extinct occur sparsely. Representatives of extant arboreal pollen shown in the diagram (Pinus, Betula, Picea) in general occur with low values with slight dominance of Pinus. Among extinct pollen coniferous types dominate greatly: Pinus haploxylon- and Inaperturate-types (Sequoia, Sciadopitys, Cypressaceae, Taxodiaceae). Of aper-turate groups only pollen grains characteristic for Middle and Middle-Lower Tertiary floras are noted.

GÄRDSLÖV CORE. ALNARP VALLEY, ALTITUDE 45.0 m a.s.l.

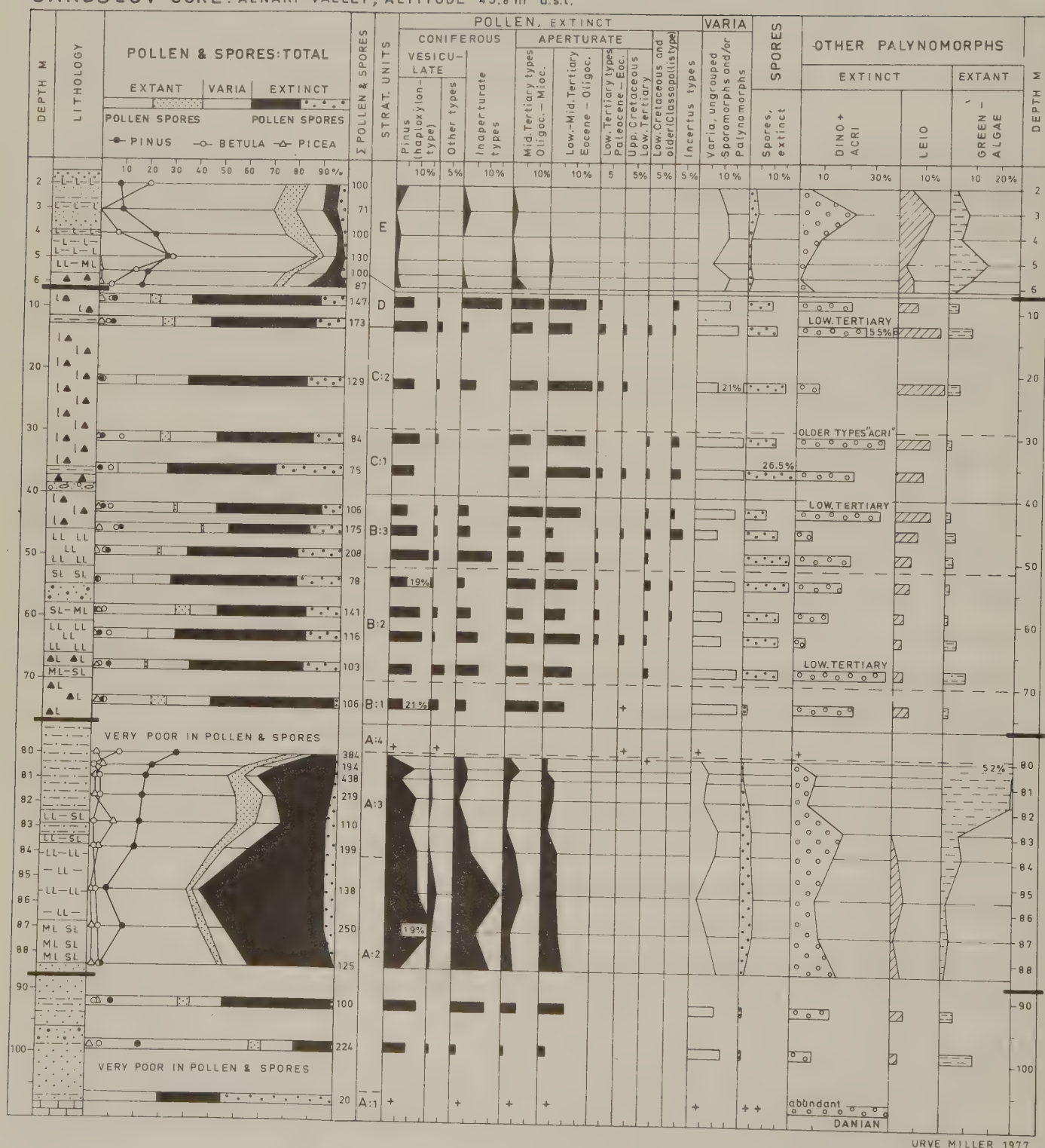


Fig 34. Gärdslov-core. Pollen and spore spectra

Subunit A:3 (84.1 - 79.9 m). Frequency considerably high. Extant pollen group dominates with Pinus as main component. Betula and Picea occur with low values. A little peak of Picea at 83 m and of Betula at 80 m. Extant spores have a slight increase between 83 and 81 m. Green-algae occur abundantly at 80, 82 and 83 m. Extinct pollen-group is composed by the same types as in subunit A:2, i.e. coniferous types and Middle to Lower Tertiary aperturate types.

Subunit A:4 (79.9 - 77 m). Extremely poor in pollen and spores. Three extant pollen grains (2 Betula nana-type and 1 of Artemisia-type noted. Six extinct pollen grains were observed (Pinus haploxylon-type, Micropinus-type and older vesiculate type, Incertus-type, Trudopollis-type and 1 Varia)

Unit B (77 - 40 m, boulder clay, fine-grained sediments and till).

Subunit B:1 (77 - 70 m, boulder clay). Frequency low. Extinct pollen group dominates. Main components are Pinus haploxylon-type and aperturate types of Middle to Lower Tertiary origin. Inaperturate types sparsely represented. Content of extinct spores very low. In the extant group pollen of trees are present with very low values.

Subunit B:2 (70 - 51.5 m, boulder clay alternating with sediments). Frequency somewhat higher, but very varying. Dominance of extinct pollen group continues, mainly composed by Lower and Middle Tertiary aperturate types and Pinus haploxylon-type. Typical Paleocene and Upper Cretaceous, together with Lower Cretaceous and older types occur in almost every spectrum. The group of extinct spores has increased to about 20%. The extant pollen group composes in general 15 - 25% of the spectra, except at 58 m, where it increases to 35%. The arboreal components are sparsely represented. Herbaceous pollen types and pollen of shrubs are the main representatives of the pollen flora.

Subunit B:3 (51.5 - 40 m, clay and till). Extinct pollen group dominates. In the lower part of the subunit slight increase of inaperturate types, in the upper spectrum again high dominance of Middle to Upper Tertiary aperturate pollen types. Lower Cretaceous and older types are present in all the spectra. The extant pollen group is best represented at 41.5 m (40%), where Pinus as well as Betula are present with about 10%.

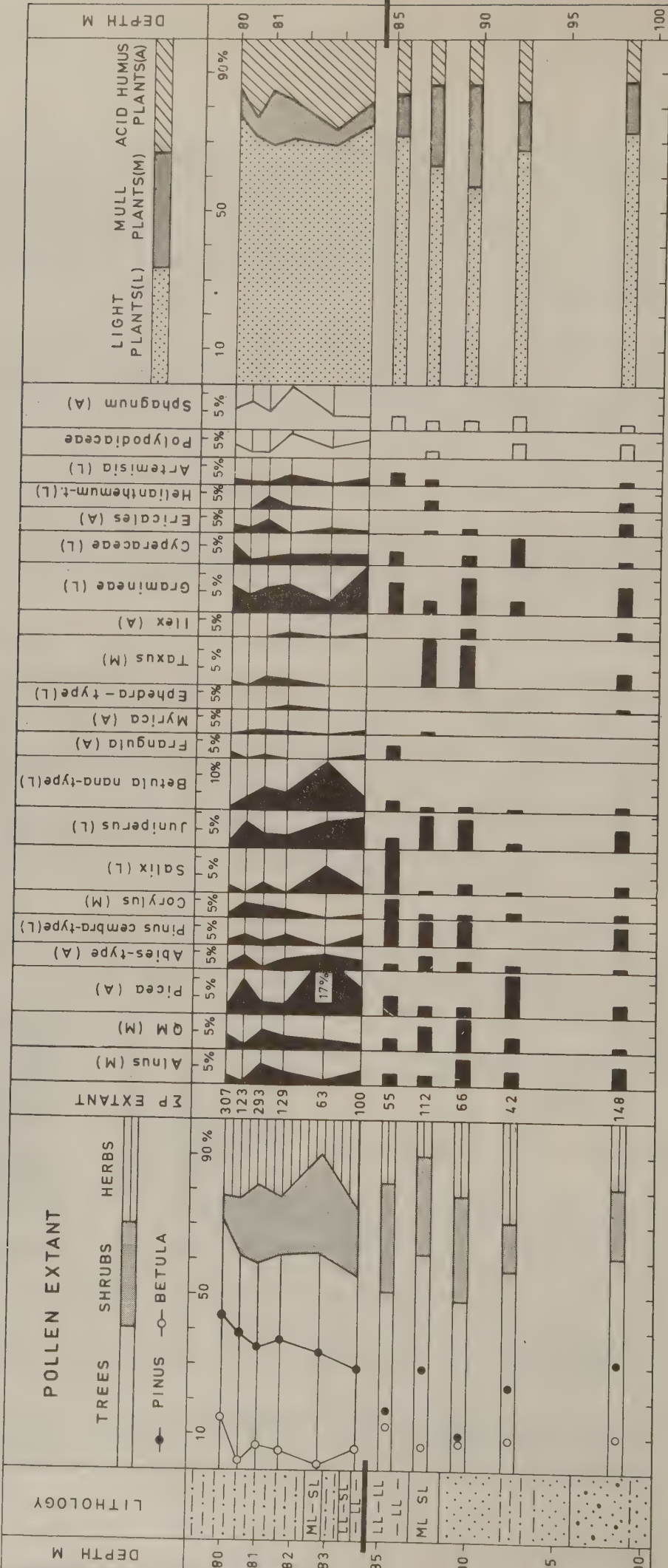
Unit C (40 - 12.5 m, clayey till).

Subunit C:1 (40 - 29.5 m, till heterogenous). Very poor in pollen and spores. Extinct pollen group, mainly composed of Lower Tertiary aperturate types, highly dominant. Lower Cretaceous types present. Paleocene and Upper Cretaceous types represented in the lower spectrum. High values of Varia group, which here partly may contain older Mesozoic and Paleozoic sporomorphs and palynomorphs. In the lower spectrum extinct spores have maximum (26%). In the upper spectrum the extant pollen group increases from 10 to 25% with Betula as main component and extinct spores decrease to 12%.

Subunit C:2 (29.5 - 12.5 m, till more homogenous). Poor in pollen and spores. Main representatives are Lower and Middle Tertiary aperturate pollen types. Inaperturate and vesiculate types present with low values. Paleocene and

Fig 35. Gärdslöv-core. Extant pollen spectra of the fine-grained sediments between 99 and 80 m.

GÄRDSLÖV. FINE-GRAINED SEDIMENTS below 80 m



Upper Cretaceous types noted. Probably the high value of the *Varia* group may depend on older sporomorphs. *Leio*-group, which originates from Paleozoic deposits has a maximum here. Extant pollen types occur with 15%.

Unit D (12.5 - 5.7 m, till, very dark in the uppermost part). Frequency of pollen and spores somewhat higher. Extinct pollen group dominates with all types distinguished present. Extant pollen group composes 20 - 25 % and extant spores about 5 % of Lower Tertiary origin are very frequent (55%) in the lower spectrum.

In the upper spectrum of the unit a distinct change to dominance of extant pollen group appears.

Unit E (5.7 - 2 m, fine-grained sediments). Extant pollen group dominates in general with 70 - 75%. Maximum at 5 m with 88%. Extant spores present with about 10% in the three upper spectra.

Extinct pollen and spores together compose 5 - 10%, represented by *Pinus haploxylon*-type. Inaperturate-types and Middle Tertiary aperturate pollen types. Green-algae have a little maximum (15%) at 5 m. *Dino/Acri*- and *Leio*-groups have peaks at 3 m.

Stratigraphical remarks: All types of till and boulder clay with interlying sediments present in the Gärdslov-core between 5.7 and 80 m have in common a low content of extant pollen types. Extinct pollen and spore types as well as other extinct palynomorph groups are well-represented and indicate admixture of material of different origin.

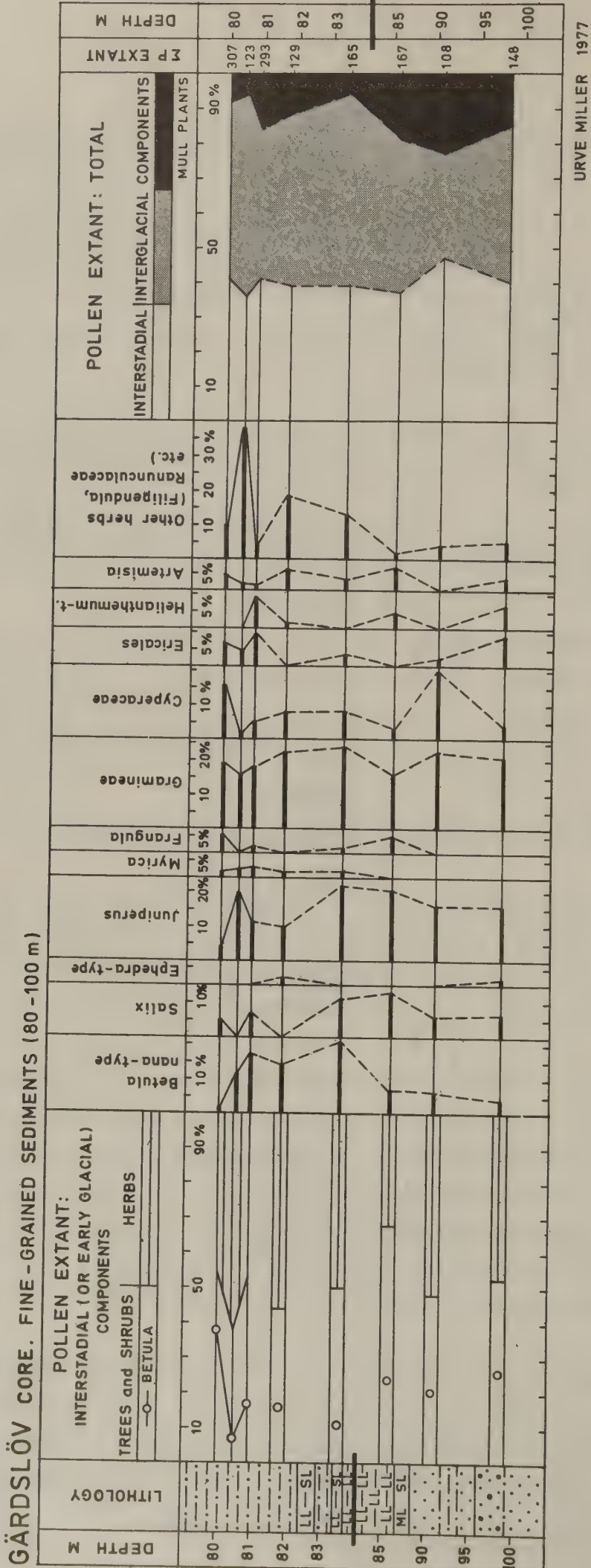
b) Extant pollen spectra of the fine-grained sediments below 80 m.

The extant pollen spectra of the fine-grained sediments 99 - 80 m (subunits A:2 and A:3) are shown in Fig 35. The content of extant pollen is between 98 - 85 m. These spectra are presented in the diagram mainly to illustrate the approximate composition of the extant pollen flora present.

It appears from the total diagram that aboreal pollen compose about 60% (50 - 70%) of the spectra. Pollen of shrubs have percentage values varying between 15 and 30%, except in the uppermost spectrum, where they compose 7%. Pollen of herbaceous plants compose 10 - 30%. The main areboreal component is *Pinus silvestris*-type. *Betula*-pollen occur in general with about 10% in the lower part and decrease to about 5% in the upper part, except in the uppermost spectrum, where they have a maximum with 15%.

The second part of the diagram presents silhouette-curves of the other components. The composition of the spectra is confusing. Among the components occur representatives for a temperate, interglacial flora (*QM-Corylus*, *Taxus*, *Alnus*) and for a subarctic (interstadial or early glacial) flora (*Betula nana*-type, *Salix*, *Juniperus*, *Artemisia*, *Ericales*).

Fig 36. Gärdslöv-core. Extant interstadial pollen spectra of the fine-grained sediments between 99 and 80 m.



The division of the components into light-, mull- and acid humus plants, shown in the third part of the diagram, illustrates the mixed character of the extant pollen flora. If the subarctic flora present is supposed to be more or less contemporary with the sediments, there seem to be four possibilities to interpret the admixture of the temperate elements in the pollen flora. They may be:

1. reworked from Upper-Middle Tertiary deposits, i.e. they are of the same origin as the main part of the extinct pollen present in the sediments. In this case probably also the coniferous components, at least the vesiculate pollen-types, are reworked from the same deposits.
2. reworked from interglacial deposits, representing a flora type from the later part of an interglacial stage, with presence of Picea and Abies, in combination with sparsely represented termophilous flora. The occasional relatively high values of Picea favourize an Eemian origin.
3. a combination of 1. and 2. with a part of the pollen-types belonging to the extinct group (mainly the coniferous pollen-types, which are difficult to distinguish from the extant ones, i.e. the vesiculate Pinus silvestris, Picea- and Abies-types and also Juniperus and Taxus-types, belonging to the extinct inaperturate pollen-group). The main part of the mull plants pollen may represent an interglacial admixture.
4. the pollen spectra represent a more or less contemporary vegetation from the end phases of an interglacial stage with some redeposition. Contamination in connection with the core drilling is also a possibility, but in this case in a downward direction as in the Hyby-core.

Presuming the subarctic components to be the contemporary ones and the more termophilous components to be of interglacial or pre-Pleistocene origin, the interstadial or early glacial pollen spectra will have an approximate composition as shown in Fig 36.

To the right in the diagram the relation between the interstadial and interglacial components are presented with the percentages of mull plants noted (cf p 60). The values of Betula-pollen included in the diagram are very uncertain as Betula partly also may belong to the interglacial reworked com-

ponents. On the contrary Pinus, which is not included in the diagram, may occur also in the interstadial spectra. It appears from the diagram that the arboreal Betula-pollen values are low when pollen of Betula nana-type have a maximum (cf Fig 37).

c) Extant pollen spectra of the fine-grained sediments 5.7 - 2 m (unit E) and the uppermost till sample (6.1 m)

The extant pollen spectra of the fine-grained sediments on the top of the Gärdslov core and the spectrum of the uppermost till sample are presented in Fig 37.

GÄRDSLÖV CORE. FINE-GRAINED SEDIMENTS (2.0-6.1 m)

Fig 37

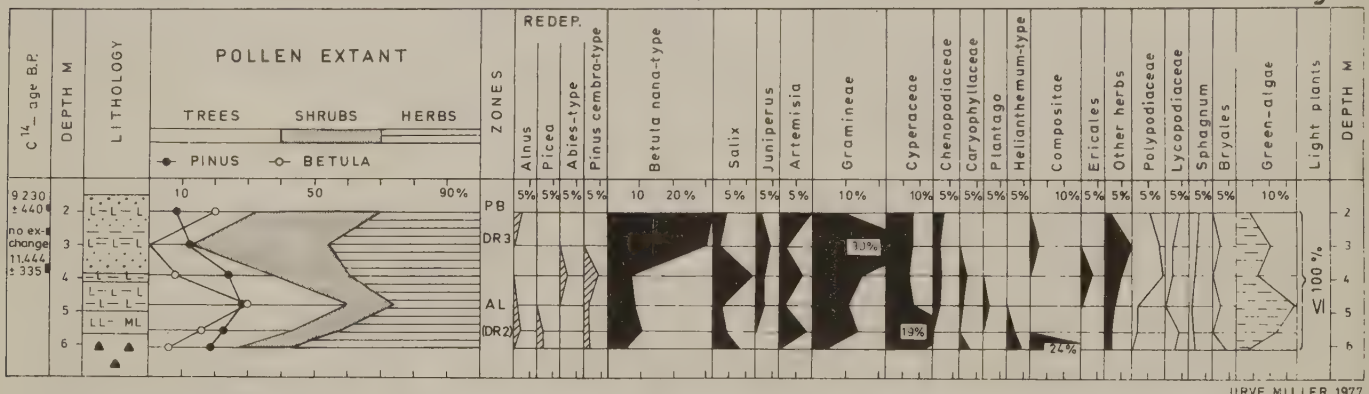


Fig 37. Gärdslov-core. Extant pollen diagram of uppermost till sample and the fine-grained sediments between 6.1 and 2 m.

The pollen spectra have a typical late glacial composition. The high percentages of Pinus-pollen partly may depend on redeposition, partly on long-distance wind-transport. The other components presumed as redeposited (Alnus, Picea, Abies and Pinus cembra/ P. mugo-type) occur very sparsely. The low content of extinct pollen in these sediment (cf Fig 34), confirms the primary character of the Late Glacial pollen flora.

The upper till surface seems to have been the first Late Glacial paleosol (DR 1-2) exposed to the pioneer vegetation, mainly composed by herbaceous plants. (Compositae, Helianthemum, Caryophyllaceae, Cyperaceae). In the clayey silt the arboreal Betula-pollen have a pronounced maximum together with a small maximum for green-algae (AL). An increase in the values of shrub pollen, mainly represented by Betula nana-type, and herbaceous pollen (Gramineae) occur upwards in the sediment sequence (DR 3). In the uppermost spectrum (2m) the arboreal Betula-pollen, which almost had disappeared at 3 m, again are present with 20% (PB).

The uppermost 2m of the core consist of sand, very poor in pollen and other microfossils. The few pollen grains noted are extant types (Betula, Pinus, Corylus, Artemisia, Cyperaceae and Thalictrum), all badly preserved and corroded.

The extant pollen spectra between 6.1 and 2 m in the Gärdslov core seem to reflect the development of the Late Glacial vegetation during Older Dryas (DR 1-2) - Alleröd (AL) - Younger Dryas (DR3)- Preboreal (PB). A closer zoning of the diagram is not possible due to the few analyses made.

Three radiocarbon datings were made on the samples from this sediment sequence with following results.

- 1.85 - 2.0 m, sand with organogenous material, St 4943, 9230 ± 440 B.P.
- 2.55 - 2.78 m, fine sand with grains of organogenous material - no exchange
- 3.68 - 3.90 m, fine sand with organogenous material, St 4945, $11\ 440 \pm 335$ B.P.

Because of the low depth and the high permeability of the overlying sand the uppermost sample (1.85 - 2 m) may have been contaminated by younger material. The ^{14}C -age seems to be a little too young. The sample 2.55 - 2.78 m had too low content of material of measurable age and gave no exchange. The sample 3.68 - 3.90 m according to the pollen spectra seems to correspond quite well to the ^{14}C -age 440 ± 335 B.P., i.e. the Alleröd-interstadial.

2.3:3:3 Siliceous microfossils, mainly Pleistocene diatoms

The alphabetic list of siliceous microfossils found in the Gärdslov core with their frequency and distribution in the different strata is presented in Table 7. The division of the core into stratigraphical units, mainly based on the content of pre-Quaternary siliceous microfossils and paly-nomorphs has been presented earlier on page 70 of the present paper.

Contrary to the Hyby - and Tofthög-cores the number of pre-Quaternary (Lower Tertiary) marine taxa identified is comparatively low, about 45 (Hyby 92, Tofthög 70). Both the poorness of siliceous microfossils in the Gärdslov -core and the degree of fragmentation are probably caused by repeated re-working.

The Pleistocene fresh-water diatoms are abundant in the uppermost fine-grained sediments between 5.7 and 3.6 m (unit E) and sporadically in unit A (fine-grained sediments 106.75 - 77.0 m), subunit B:3 (sediments and till 51.5 - 40.0 m) and unit D (till 12.5 - 5.7 m).

In the fine-grained sediments of unit A the following freshwater taxa were noted: 1 Melosira arenaria and 1 Melosira islandica (both clear-water species), 1 Cymatopleura cf solea fragment, 1 Navicula mutica (aerophilous, alkaliphilous) and 5 pennate fragments unidentified.

In the subunit B:3 the fresh-water diatoms noted were very corroded and fragmented. 5 frustules of 5 different taxa could be identified. (Epithemia sp., Fragilaria construens, Fragilaria construens v. venter, Nitzschia sp., Synedra ulna). They mainly represent alkaliphilous to pH-indifferent taxa. Moreover 5 pennate fragments were noted.

In the unit D only 2 identified specimen (Hantzschia amphioxys, Tabellaria flocculosa) and 4 fragments were noted. The fragmented character and sporadic occurrence favours reworking.

The comparatively abundant Pleistocene fresh-water flora of unit E, Fig 38 of primary character is of Late Glacial type, with the main part of the species belonging to alkaliphilous flora. Similar flora type is described from the nearby situated Late Glacial sediments at Skurup (Robertsson 1973). The flora is mainly composed of epiphytic and benthic diatoms which prefer alkaline to circum-neutral, sometimes slightly haline environment, rich in mineral salts (unleached Late Glacial soils). The water-depth in the Late Glacial Gärdslov lake have been comparatively low as planktic forms are absent and the genera Fragilaria, Epithemia, Cymbella and Amphora dominate.

Fig 38 shows the main composition of the diatom spectra from the upper part of the Gärdslov-core (6.4 - 2.5 m). The almost entirely pre-Quaternary siliceous microfossil spectrum at 6.4 m, very abruptly changes to a Pleistocene (Late Weichselian) fresh-water flora in the sediment sample upon the till. The Pleistocene fresh-water flora dominates to 3.6 m. In the sand layer from 3 m and upwards no siliceous microfossils were noted.

GÄRDSLÖV: SILICEOUS MICROFOSSILS 2.55 6.40 m

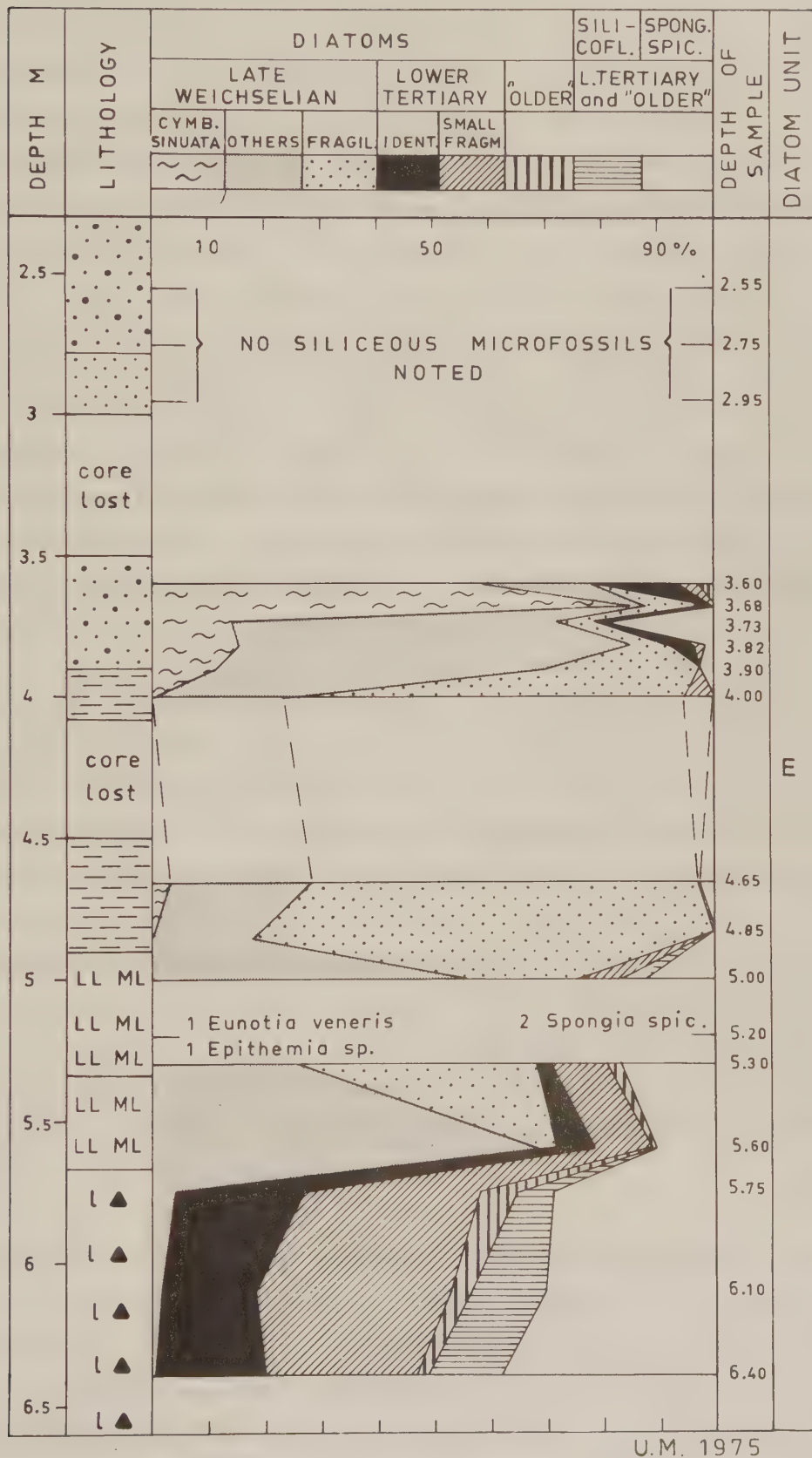


Fig 38. Gärdslov-core. Relation diagram between the different groups of siliceous microfossils in the uppermost part of the core between 6.4 and 2.5 m.

2.4. Comparison of the microfossil spectra and stratigraphy of the three bore-cores: Tofthög, Hyby and Gärdslöv

The 10 stratigraphical units of the Tofthög core, divided after their microfossil spectra (Miller 1971), in general correspond to the lithostratigraphical units of the Tofthög core (K. Nilsson 1971). In the diagram of total microfossil content/spectra (Fig 24) the division in units is made for siliceous microfossil spectra and palynomorphic spectra separately, to prove the stratigraphical applicability of the different spectra types. As seen from the diagram the microfossil spectra (Miller 1971) and the palynomorphic spectra greatly correspond to each other, except some smaller dislocations between the unit boundaries 3/4, 4/5 and 6/7. Concerning the diatom spectra the differences are more obvious. It seems to depend on the fact that compared with palynomorphic spectra the siliceous microfossil spectra represent deposits limited to 1) the Danian bedrock (transformed frustules), 2) the Lower Tertiary marine deposits, probably mainly of Eocene age (marine diatom flora), 3) Quaternary (Pleistocene) limnic sediments (fresh-water flora - not noted in the Tofthög core). Consequently the pre-Quaternary part of the diatom spectra reflects either a material content originating from the more or less local bedrock (Danian) or from Lower Tertiary marine (Eocene) deposits, reworked by an old Baltic ice-stream and brought reworked to the Alnarp Valley from a supposed south-eastern direction. The Quaternary (Pleistocene) part of the diatom spectra reflects primary interglacial or interstadial conditions, or an admixture of reworked interglacial or interstadial sediments, (cf Mohrén in Ekström 1953, K. Nilsson 1971, 1973).

The diatom spectra of the Tofthög core confirm very well the statement concerning the pre-Quaternary parts of the spectra. In the younger deposits of the Alnarp Valley (deposits overlying the Old Baltic till) the Eocene diatoms are always present, but only to a comparatively low extent. In the youngest Baltic till (Low-Baltic) a tendency to higher content of siliceous microfossils sometimes appears.

The division into diatom spectra is based mainly on

- 1) the frequency of siliceous microfossils
- 2) the presence or absence of Eocene diatoms
- 3) the presence or absence of transformed frustules
- 4) the presence of Pleistocene diatom floras of primary character, and
- 5) the degree of fragmentation.

The palynomorphic spectra contain palynomorphs of very heterogeneous origin. They represent all the sedimentary bedrock of Scania and the Baltic from Cambro-Silurian up to Tertiary. As regards the division into palynomorphic units the main factors of concern are:

- 1) the proportions in relative frequency between the extant and extinct groups of palynomorphs
- 2) the frequency of palynomorphs
- 3) the dominant group or groups of certain palynomorphs as characteristic component or components.

The division made on bases of all palynomorphic components seems to coincide well with the stratigraphical records of pollen and spore spectra. It must depend on the same origin in general, concerning Dino/Acri-group and extinct pollen and spores. The Leio-group presumed to represent the admixture of Cambro-Silurian bedrock material in the Quaternary deposits, stratigraphically is of somewhat uncertain value, as it occurs (probably reworked) in almost all the sedimentary bedrock from Cambro-Silurian up to Tertiary (G. Kjellström, oral comm, Tynni 1975).

The groups of Dino/Acri and extinct spores may be stratigraphically exploited to a much greater extent than in the present investigation. Both groups contain stratigraphically well-limited representatives (guide fossils), which could be very useful in future work with Quaternary stratigraphy in Scania. Concerning the present investigation, their high relative frequencies only reflect an admixture of sedimentary bedrock of Lower Tertiary, Upper Cretaceous or older age. Concerning Dino/Acri-group Dr Göran Kjellström, SGU, has helped the author with information about the primary stratigraphical origin of the dinoflagellate floras, abundant in some samples analysed. His information, together with the authors own observations, is included in some diagrams and in the short characteristics of the stratigraphical microfossil units of the Alnarp Valley presented below.

Thus the stratigraphical results concerning the core-material from the Alnarp Valley, are based mainly on the content of siliceous microfossils and pollen, with some complementary information from the other palynomorphic groups. The stratigraphical units distinguished below will be compared between the cores and a somewhat simplified and coordinated stratigraphical division system for the Alnarp Valley will be presented. A tentative correlation of the units between the cores is shown in Fig 39.

Key to litho-/biostratigraphical microfossil units of the Alnarp Valley.
(d = diatom unit, p = palynomorphic unit)

<u>Strat. unit</u>	<u>Lithology</u>	<u>Hyby</u>	<u>Gärdslov</u>	<u>Tofthög</u>	
11	sediments	absent	E	absent	
10	sediments	absent	absent	dIX	p10
9	till	absent	D	dVIII/IX	p9
8	till + sed.	absent	absent	dVIII	p8
7 ^V	till	d8 p7:2	C:1, C:2	absent	
7 ^{IV}	till + sed.	d7b p7:1	B:3	absent	
7 ^{III}	till + sed.	absent	B:2	dVIII	p7
7 ^{II}	till	absent	B:1	absent	
7 ^I	sediments	d7a p6	absent	dVII	p6
6 ^{III}	sediments	absent	A:4	absent	
6 ^{II}	sediments	d6 p6	A:3	dVI	p6
6 ^I	sediments	d6 p6	A:2 (partly)	dVI	p6
5	mainly sed.	d5 p5	absent	dV/VI	p5/6
4 ^{II}	sediments	d4b p4	absent	dIV/V	p4/5
4 ^I	till	d4a p4	absent	dIV	p4
3 ^{II}	sediments	d3b p3:3	absent	dIII	p3
3 ^I	sediments	d3a p3:2	absent	absent	
2	till + sed.	absent	absent	dII	p2
1	bedrock	d1(+3)p(3:)1	A:1	dI	p1

The 11 main stratigraphical units distinguished in the Pleistocene core material from the Alnarp Valley are:

Unit 1: Danian bedrock and crack-filling. - Transformed siliceous frustules. Dinoflagellates (Maastrichtian-Danian forms according to G. Kjellström).

Unit 2: Lowermost till with underlying sediments in Tofthög. - Eocene diatoms not present. Extinct pollen and spores (Lower Cretaceous and older types present). - Microfossil content indicates ice-movement from north or north-east (so-called Old NE-till, cf K. Nilsson 1971, p. 500).

Unit 3^I: Fine-grained sediments in the Hyby-core. - Extant pollen of interglacial origin. Pleistocene fresh-water diatoms, mainly planktic and green-algae indicate lacustrine sedimentation. - Microfossil content indicates interglacial sedimentation.

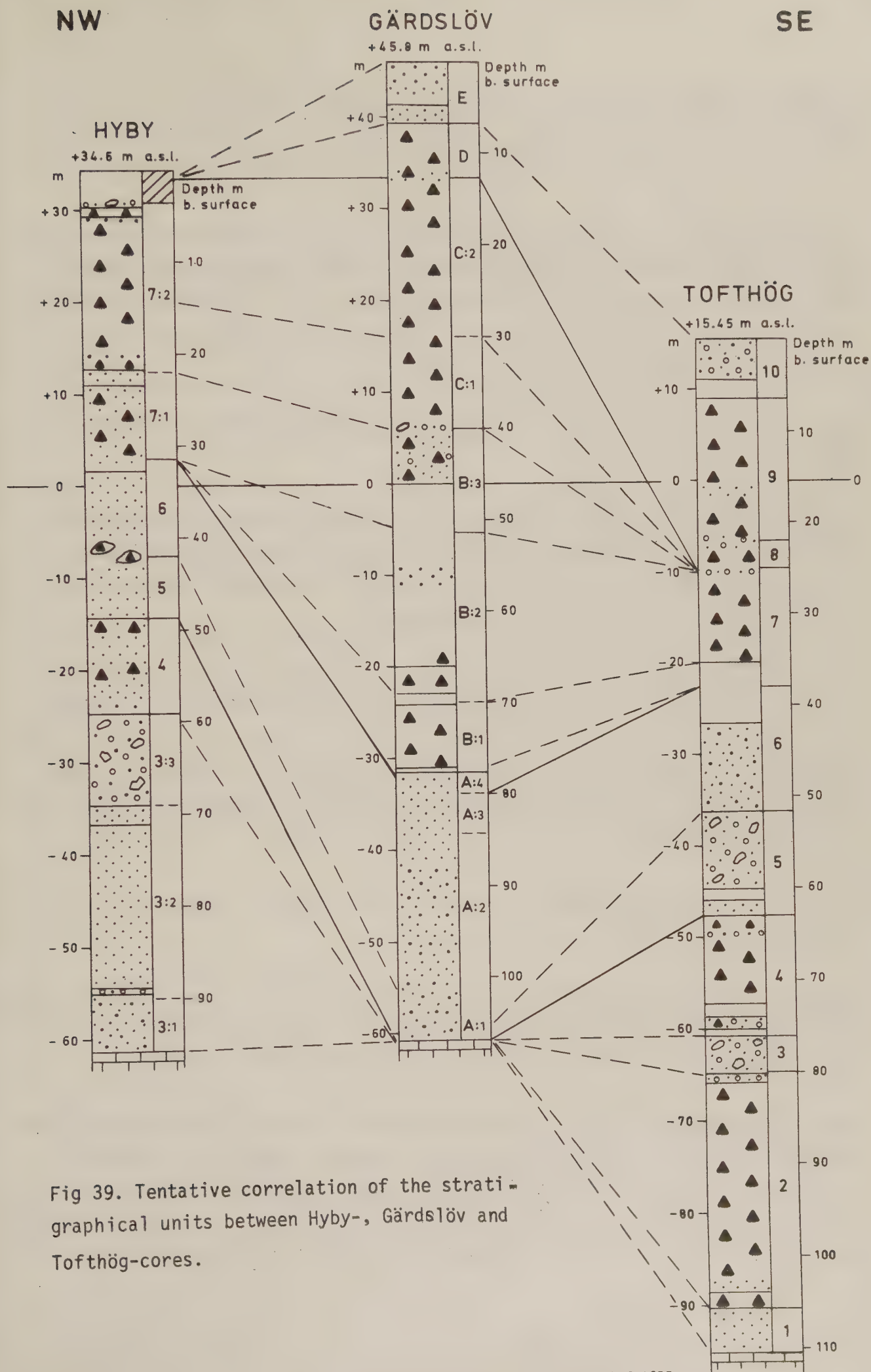


Fig 39. Tentative correlation of the stratigraphical units between Hyby-, Gärdslöv and Toftthög-cores.

Unit 3^{II}: Coarse sediments, mainly crushed Cretaceous limestone. - Very poor in microfossils. - Local glacial erosion (cf p 12, Mohrén in Ekström 1953, p. 22 and K. Nilsson 1971, p. 501).

Unit 4^I: Boulder clay of Baltic type with high content of Cambro-Silurian limestone. In Hyby mixed with sediments. - Eocene diatoms abundant. Extant coniferous pollen. Dinoflagellates of Lower Tertiary origin. - According to microfossil content so-called Old Baltic till, ice-movement from south-east (cf K. Nilsson 1971, p. 501 and 505).

Unit 4^{II}: Sandy-silty sediments. Content of siliceous and other microfossils low.

Unit 5: Sediments of varying coarseness. In the Hyby core probably mixed with boulder clay. - Eocene diatoms abundant to common. In Hyby core traces of Pleistocene marine diatoms. Extant pollen common. - Microfossil content indicates redeposition of interglacial sediments.

Unit 6^{I-II}: Fine-grained sediments. - Relatively high content of extant pollen of interglacial (or early glacial) origin. Green-algae. Transformed siliceous frustules common. Eocene diatoms present sparsely. In the Gärdslov-core fluvial sedimentation registered by occurrence of cross-bedding. - Microfossil content indicates interstadial sedimentation with redeposition of interglacial and pre-Quaternary material.

Unit 6^{III}: Fine grained sediments very poor in microfossils. Present only in the Gärdslov-core. Glacial sedimentation.

Unit 7^I: Fine-grained sediments. In Hyby mixed with till. - Eocene diatoms common. Transformed frustules almost absent. Extant pollen dominate. - Microfossil content indicates redeposition of interglacial or interstadial sediments.

Unit 7^{II}: Boulder clay of Baltic type with high content of Cambro-Silurian limestone. Present only in the Gärdslov-core. - Eocene diatoms occur sparsely. Extinct palynomorphs dominate, mainly pollen (Lower and Middle Tertiary) and Lower Tertiary dinoflagellates. - According to microfossil content not so-called Old Baltic till (see p 96). Ice-movement probably from more eastern direction.

Unit 7^{III-IV}: Till and fine-grained sediments. - Poor in microfossils, mainly extinct palynomorphs. - Microfossil content indicates ice-movement from northern or north-eastern direction (NE-till, see p 96).

Unit 7^V: Till, homogeneous. - Very poor in microfossils. Mainly extinct palynomorphs. - Microfossil content indicates ice-movement from northern direction (N-NE-till, see p 96).

Unit 8: Till, heterogeneous with interlying coarse sediments. Present only in the Tofthög-core. Extant pollen dominate. - Microfossil content indicates ice-movement from south-east (Young Baltic till, see p 96).

Unit 9: Till (boulder clay) of Young Baltic type. Lower Tertiary dinoflagellates and extant pollen. Eocene diatoms common. - Microfossil content indicates ice-movement from south-east (SW- or Low Baltic till, cf Mohrén in Ekström 1953 and K. Nilsson 1971, p. 504).

Unit 10: Sediments of varying coarseness. Present only in the Tofthög-core. Almost the same microfossil content as the underlying till, indicating the sediments to be connected with the Low Baltic till.

Unit 11: Fine-grained sediments. High content of extant pollen of Late Glacial origin. Pleistocene fresh-water diatoms and green-algae. Present only in the Gärdslöv-core. - Microfossil content indicates Late Glacial sedimentation.

3. DISCUSSION AND COMMENTS

3.1. Correlation with other borings and sections in and near the Alnarp Valley

In the scope of the present investigation also material from several well-borings, gravel pits and other sections in and near the Alnarp Valley has been preliminarily analysed to check the microfossil content. These, comparative studies will not be presented in this paper of several reasons:

1. Many of the borings or sections studied belong to other scientists unpublished research works (cf page 19).
2. More effective concentration methods for microfossil analysis have been developed and now put to the test at the Micropaleontological laboratory, SGU (Juvigné 1973 a, b, Woillard 1975, Stanichnikova 1975, Pâsse 1976). The results seem to be promising with 10 - 20 times better concentration of the palynomorphs. The enormously time-consuming analysis work and the statistically weak results, have been the most difficult obstacles connected with the present work. If these hazardous difficulties can be reduced, use of reworked microfossils to characterize and stratigraphically define complex minerogenous Quaternary deposits, should have a bright future.
3. The material from well-borings is not of the same stratigraphical value as core-material. The samples from well-borings are of greatly mixed composition, often taken at large intervals. The risk of contamination from overlying strata is obvious.

One of the preliminarily analysed well-borings (No. 12 in K. Nilsson 1973), situated in the Alnarp Valley south-east of Tofthög, near Abbekås, appears to have a good correlation with the Tofthög-core. (The lithostratigraphy of the bore-hole 12 and some data concerning the lithological composition of its different strata are published in K. Nilsson 1973, page III.) The abundance of Eocene diatoms in the two samples analysed from the boulder clay between 40 and 30 m indicates an Old Baltic origin of the material (p 96). The underlying silty sediments contain no Eocene diatoms. They may represent the fine-grained stratum (Alnarp Valley unit 3^I), which is absent in the Tofthög core, but present in the Hyby-core (p. 50, Fig 27).

K. Nilsson (1973) has suggested a correlation between the Baltic till in Gärdslov and the Old Baltic tills in Tofthög and Hyby. In his earlier publication Nilsson was of another opinion, presuming the Old Baltic till in Tofthög (Tofthög II) to be of Saalian age (K. Nilsson 1971). This interpretation agrees better with the results of the present investigation. The till Nilsson mentions (K. Nilsson 1973) from the bore-holes 11 and 13 (situated south-east from Tofthög) underlying the Alnarp sediments, may then as he suggests, also be of the Old Baltic type, indicating an ice movement from east or south-east. Mohrén (in Ekström 1953) has differentiated a lower lacustrine fine-grained sediment sequence and an upper fine-grained sediment sequence ("Grävie sand"), interlain by a Baltic till with high content of limestone (cf p 11). This till probably may represent the Old Baltic till. In this case the Quaternary stratigraphy of the Alnarp Valley proposed by Mohrén, corresponds in this part to the results of the present investigation.

The correlations made between the Pleistocene deposits in the Alnarp Valley and the Quaternary strata at Örsjö, situated close to the north-eastern boundary of the Alnarp Valley, will be briefly discussed here. According to Lagerlund and O. Andersson (Berglund, et al 1976, p 181) the lithological composition of the lowermost till at Örsjö shows a very good correlation with the lowermost till that covers the sequence of fluvial and lacustrine sediments in the Alnarp Valley. These sediments are supposed to have been formed during the Middle Weichselian interstadial (K. Nilsson 1973) and consequently all Quaternary strata at Örsjö belong to the Late Middle Weichselian.

The preliminary microfossil analyses of the Örsjö material confirm that the lowest till at Örsjö has the same type of microfossil content as lowest till at Gärdslov (Alnarp Valley unit 9^{II}) overlying the fluvial sediments. The lithostratigraphical results in this case agree well with the microfossil analyses. From the results of the present investigation it should be emphasized that the lacustrine sediments of the Alnarp Valley may be covered by a till, whose lithological composition is similar to the lowest till at Örsjö and Gärdslov, but whose microfossil content clearly indicates an Old Baltic origin (reworked marine Eocene diatom flora).

The Baltic till which overlies the fluvial fine-grained sediments in Gärdslov and also is present at Örsjö (Lagerlund in Berglund et al 1976) seems to have an extension limited to the Gärdslov-Örsjö area, as it is absent in Tofthög, Hyby and also in the north-western part of the Alnarp Valley (Mohrén in Ekström 1953).

Concerning the correlations of the interglacial strata at Stenberget-Romeleåsen (Berglund & Lagerlund in prep) the preliminary microfossil analyses indicate that the tills which underlie the interglacial sediments are not of the Old Baltic type (p 96). It may depend on the situation of the locality i.e. local circumstances, caused by the differences in the topography (altitude) between the Alnarp Valley and the horst Romeleåsen.

3.2. Correlation with other stratigraphical investigations of the Pleistocene in ice-margin areas adjacent to Scania

The intensified research concerning the Pleistocene stratigraphy and biological development of the ice-margin areas in northern Europe has resulted in a large number of publications. Besides the important papers of Andersen (1961, 1965 b) Andersen et al (1960), Zagwijn (1963, 1973, 1974), Zagwijn & Paepe (1968), van der Hammen et al (1967, 1971), there are the publications of Menke (1968, 1970, 1972, 1975, 1976), Menke & Behre (1973), Erd (1970), Mangerud (1970, 1972, 1973), Mangerud et al (1974), Lundqvist (1967, 1971, 1974), Korpela (1969), Woillard (1975), concerning north-western Europe. In north-eastern Europe the publications of Cepek (1967, 1972), Serebryanny & Raukas (1970), Danilans (1966), Kondratienė (1965), Liivrand (1971, 1972, 1974), Raukas (1973), Liivrand & Saarse (1976), Velitschkovitsch & Liivrand (1976) etc have presented new aspects and theories concerning the Quaternary glaciations and their extension, climatic conditions and vegetation development during the interglacial stages and interglacial substages.

T. Nilsson (1972) and West (1968) have compiled works on the geological and biological development of the Pleistocene. Nilsson describes the conditions throughout the world, while the book of West is written with special reference to the British Isles.

In the Soviet Union several comprehensive publications concerning the last glaciation in Europe and its geochronology have been published (Tschebotareva & Makarytscheva 1974, Gudelis 1973), and compiled works as "Geochronology of the USSR" 1974, "Stratigraphy and paleogeography of Antropogene" 1975.

Some correlations with other ice-margin areas are mentioned earlier in the text (p 65) with regards to the Danish interglacial fresh-water deposits of Holsteinian stage (Andersen 1965b Foged 1960, 1962). The Skaerumhede deposits

and other Pleistocene strata in Denmark have been investigated by foraminiferal studies (Feyling-Hansen 1971, Petersen & Konradi 1973, Bahson et al 1973, Konradi & Knudsen 1973, Konradi 1976) and found to contain primary marine Eemian faunas, as well as redeposited interglacial faunas and interstadial arctic faunas. As these deposits contain marine sediments, they are not directly comparable with the Alnarp deposits. The same is valid for the Eemian and the Weichselian deposits in Norway (Feyling-Hansen 1964, Mangerud 1970, 1972) and Finland (Brander 1937, 1941, Donner 1971, Donner & Gardemeister 1971). Microfossils in tills have been studied by Florin (1975) and Garnes (1976). Previous literature concerning microfossil analysis of till material is presented in Andersen (1965a) and Miller (1971).

The reference lists in Lundqvist (1974) and Mangerud et al (1974) comprise the main part of the publications concerning Pleistocene interglacials and interstadials in northern Europe. Tentative correlations with some of them will be presented in 3.3.2. (p 96) in connection with the biostratigraphical discussion.

3.3. Alternative possibilities of the interpretation according to: litho-, bio-, chronostratigraphy and radiocarbon datings

3.3.1. Lithostratigraphy

Lithostratigraphically the microfossil spectra mainly reflect the composition of a silt fraction (0.002 - 0.06 mm) and partly a fine sand fraction (0.06 - 0.2 mm). As it appears from the diagrams the dominant extinct microfossil groups are of Tertiary origin. At the fine-gravel analysis the rock fragments counted do not register the content of fine-grained unconsolidated Tertiary deposits (p 5).

The two types of total microfossil spectra (siliceous microfossils and paly-nomorphs) lithostratigraphically applied in the present investigation, reflect the composition independent of each other. The different till types occurring in the core material from the Alnarp Valley are clearly distinguishable by means of their reworked microfossil spectra.

The different till units are tentatively named according to the traditional system of classifying ice-streams in Scania (Mohrén in Ekström 1953, K Nilsson 1959, 1971, 1973, Möller 1959 etc) to facilitate the correlations with the earlier

publications. In the future, however, a new terminology which follows the international rules (norms) of stratigraphical classification terminology and usage (Hedberg 1972 a, b) has to be applied also in the Scanian stratigraphy (Berglund & Lagerlund in prep).

The five main till types distinguished are:

- 1) Young Baltic tills (Low Baltic, Middle Baltic)
- 2) North-Eastern tills (N and NE tills)
- 3) Baltic till
- 4) Old Baltic till
- 5) Old Northern till

Concerning four of the five till types distinguished the results of fine gravel analysis and microfossil analysis are in good agreement on the whole. The only till type with contradictory results is the so-called Old Baltic till. Fine gravel analyses do not register differences in composition between the Baltic and the Old Baltic till types. Microfossil analyses show a clear difference. The Old Baltic till has a high content of Eocene marine diatoms, while in the Baltic till the admixture of Eocene diatoms is much smaller, about the same as in Young Baltic tills. Consequently, according to the microfossil content spectra, the Baltic and Old Baltic tills represent different ice-movements. The Old Baltic stratigraphically has to be the older one. With regards to the lithological composition the Baltic and Old Baltic tills may represent the same ice-movement.

The fine-grained sediments, which may underlie the Baltic till (Gärdslov) or the Old Baltic till (Hyby) are lithostratigraphically assumed to be of the same age, so-called Alnarp sediments (K. Nilsson 1973, Lagerlund in Berglund, et al 1976). For that reason there has been a lithological confusion concerning the stratigraphical position of the tills overlying the so-called Alnarp sediments and the sediments themselves.

3.3.2. Biostratigraphy

The biostratigraphical results are based on the content and composition of extant microfossils, i.e. Pleistocene diatoms, interglacial-/interstadial pollen floras and other extant palynomorph groups (green-algae, spores,

rhizopods). The extant microfossils present may be contemporary with the sedimentation (primary) or reworked from older deposits (secondary). The microfossils may originate from Pleistocene interglacial and interstadial sediments and partly also from pre-Pleistocene deposits, as many of the extant palynomorph types were present already in the Middle and Upper stages of the Tertiary period. The difficulty is to decide which of the extant taxa are really primary.

The primary extant microfossil spectra register the sedimentological and climatological conditions prevailing at the formation of the sediments. The composition of the extant microfossil groups and the succession of the components are decisive for the interpretations concerning the age and the character of the sediments.

The present results obtained from the extant, supposed as primary, spectra are independent of the results obtained by the lithostratigraphically applied reworked microfossil spectra. If the stratigraphical results of the different types of analyses applied coincides, then the interpretations must be reliable.

Primary extant microfossil spectra, which in their composition and succession of components indicate vegetational development, are present in the 1) Hyby-core, fine-grained sediments below 68.5 m (Fig 30) 2) Gärdslov-core, fine-grained sediments above the uppermost till 6.1 - 2.0 m (Fig 37).

The uppermost sediments of the Gärdslov-core are of Late Weichselian age, indicated by the stratigraphical position (above an Young Baltic - Low Baltic till), radiocarbon datings and extant pollen spectra (discussed on p 82 , Figs 37, 38).

The fine-grained sediments below 68.5 m in the Hyby-core are assumed to be of interglacial origin (p 59). The composition and the development of the vegetation (indicated by the extant pollen-spectra) the lacustrine environment (indicated by the fresh-water diatom flora and green-algae), show similarity with the conditions prevailing during the Holsteinian interglacial. This interpretation is confirmed by the stratigraphical position of the sediments. They are overlain by coarse sediments and boulder clay + sediments with high content of Eocene diatoms, i.e. the Old Baltic till of presumed Saalian age, the Warthe-stadial (discussed by K. Nilsson 1971, 1973).

An alternative interpretation would be that the pollen spectra reflect some of the later warm-temperate Saalian interstadials (Fig 40) called Dömnitz/Wacken and Treene in northern Germany (Cepek & Erd 1970, Menke 1972, Menke & Behre 1973) and Hoogeveen and Bantega in the Netherlands (Zagwijn 1973). The early Saalian interstadials in Denmark, Vejlbj I and Vejlbj II (Andersen 1965b) represent colder climatic conditions.

E e m i e n	
E x i s a a l e	- Stade V, très froid (= Stade III de Zagwijn, 1973) (= Warthe de Menke & Behre, 1973)
	- Interstade de Bantega, chaud (Zagwijn, 1973) (= Treene de Menke & Behre, 1973)
	- Stade IV, froid (= Stade II de Zagwijn, 1973) (= Lippe de Menke & Behre, 1973)
	- Interstade de Hoogeveen, chaud (Zagwijn, 1973) (= Wacken de Menke, 1972 ou Dömnitz de Erd, 1970)
	- Stade III, très froid (= Stade I de Zagwijn, 1973) (= Mehlbeck de Menke, 1972)
	- Interstade de Vejlbj II, tempéré (Andersen, 1965)
	- Stade II, froid (Andersen, 1965)
	- Interstade de Vejlbj I, tempéré (Andersen, 1965)
	- Stade I, froid (Andersen, 1965)
H o l s t e i n i e n	
E l s t e r (Mindel)	

Fig 40. Chronology of Holstein - Saale in northern Germany, the Netherlands and Denmark (after Woillard 1975, p 76, Tab VII).

The interglacial sediment sequence in the Hyby-core is the first find in Sweden of presumed pre-Eemian age. For that reason it is advisable to be cautious with the interpretations and correlations until statistically more valid analyses, preferably made on core-samples of better quality, can be presented.

In the extant pollen spectra of the fine-grained sediments in the Gärdslöv-core below 80 m and in the Hyby-core between 48.4 and 31.5 m a redeposited (interglacial) pollen flora dominates. In the pollen spectra of the Gärdslöv

sediments representatives for a subarctic tundra flora are present. If the three radiocarbon datings of the Gärdslov sediments (approx. ages 27 500, 23 000 and 21 500 B.P., discussed on p 100) correspond to the approximate ages of the sediments, then the sequence of the fluvial sediments is of Middle Weichselian age, corresponding to the age of the Göta älv interstadial (Brotzen 1961, Miller 1964) in western Sweden and may be correlated with many of the other localities where the sequence of sediments dated belong to the upper part of the Middle Weichselian interstadial complex in the northern Europe (cf the compilation and reference list in Lundqvist 1974). Some mammoth finds of southern Sweden have also been dated to the period 20 000 - 40 000 years B.P. indicating interstadial conditions (Bergrlund et al 1976).

3.3.3. Radiocarbon datings and chronostratigraphy

Of the core material from the Hyby and Gärdslov borings 23 samples were taken out for ^{14}C -dating, all of them containing small amounts of organogenous material noted visually. A list of the samples with data about their depth and kind of material is presented below together with the results obtained from the Laboratory for isotop geology, Stockholm. Reference year in the B.P. system is A.D. 1950. $T_{1/2} = 5560 \pm 30$ years.

Depth m below surface	Material	^{14}C -age	No.
<u>Gärdslov</u>			
1.85 - 2.00	sand, medium-fine	9 230 $\pm$ 440	St 4943
2.55 - 2.78	sand, fine	no exchange	
3.68 - 3.90	sand, fine	11 440 $\pm$ 335	St 4948
79.97 - 80.28	silt, clayey	32 880 $\pm$ 1770	St 4946
80.33 - 80.83	silt, clayey	> 34 000	St 4274
80.33 - 80.83	silt, clayey	32 730 $\pm$ ²⁸⁰⁰ ₂₀₄₀	St 3158
80.70 - 81.01	silt, clayey	21 305 $\pm$ 3000	St 4273
81.83 - 82.00	silt, clayey	> 35 000	St 4272
88.40 - 88.68	sand, fine, clayey	22 835 $\pm$ 1680	St 4938
98.40 - 98.83	silt	27 535 $\pm$ 5000	St 4271

Hyby (core)

33.30 - 34.15	sand, fine	no exchange	
35.50 - 35.70	sand, fine, silty	> 35 000	St 4275
35.50 - 35.75	sand, fine, silty	no exchange	
36.35 - 36.50	sand, fine, silty	no exchange	
68.62 - 69.00	silt	no exchange	
69.10 - 69.40	clay, microstrat.	31 425±5400	St 4961
69.10 - 69.60	clay, microstrat.	36 995± ²⁸⁶⁵ ₂₀₄₀	St 3158
74.65 - 74.85	silt	no exchange	
76.90 - 77.12	sand, fine, silty	no exchange	
87.00 - 87.55	sand, fine, silty	31 380±5880	St 5093

(mixed samples)

76.40 - 76.90	silt with gyttja	no exchange
78.80 - 79.40	silt with gyttja	no exchange
80.70 - 81.45	silt with gyttja	no exchange

Gärdslov. Of the 10 samples from the Gärdslov-core date, 9 have given finite ages. The only sample with no exchange is the middle one (2.78 m - 2.55 m) of the Late Glacial sediments from the uppermost part of the core. The content of organogenous material was too low for C¹⁴-dating. The ¹⁴C-ages of the samples 2.00 - 1.85 m and 3.90 - 3.68 m are discussed aerlier in the present paper (on page 83).

The ¹⁴C-datings of the fine-grained sediments 98.83 - 79.97 m have all given finite ages. The ¹⁴C-ages may be divided into two groups > 30 000 B.P. and < 30 000 B.P. The higher ages are concentrated to the upper part of the fine-grained sediments, the younger ages to the lower part, with exception of the sample 81.01 - 80.70 m, which has the lowest value of all the 7 datings 21 305±3000 B.P. The results are shown in Fig 41.

Following interpretations of the varying ¹⁴C-ages are conceivable:

- 1) The samples may be contaminated by older organogenous material (Quaternary interglacial and pre-Quaternary), caused by redeposition. Then the formation of sediments has to be younger than the ¹⁴C-ages which is unreliable.
- 2) The samples may be contaminated by younger organogenous material (interstadial and recent) in connection with the core-drilling, storing and sampling.

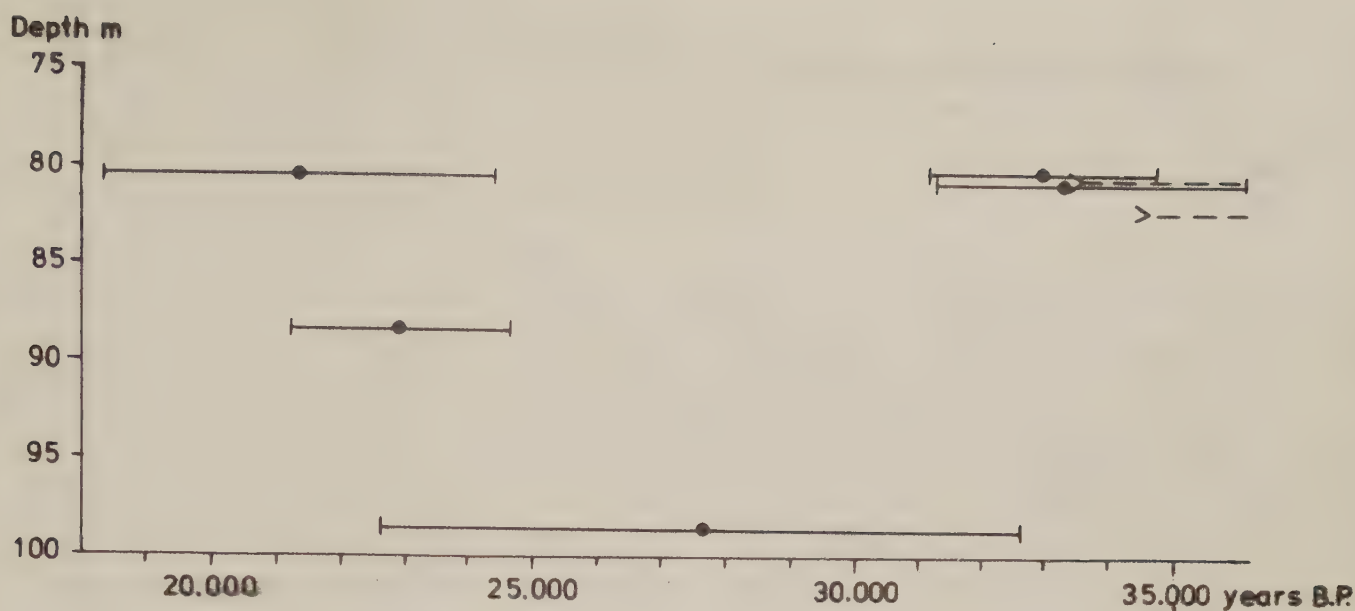


Fig 41. Gärdslöv - core. The ages of the radiocarbon datings of the fine-grained sediments below 80 m.

Then the sediment formation has to be older than the ^{14}C -ages, which not is confirmed by the results of microfossil analyses.

3) The ages < 30 000 B.P., correspond approximately to the age of the sediment formation, while the ages > 30 000 B.P. are too high on account of redeposited older organogenous material according to point 1) above. The third possibility seems to be the most plausible one according to the results of the present investigation, i.e.

- a. palynomorphic and pollen spectra show admixture of pre-Quaternary, as well as interglacial and interstadial components.
- b. all the strata between the Late Glacial sediments, in the uppermost part of the core, and the fine-grained sediments below 80 m, seem to be of glacial origin.

Hyby. Altogether 13 samples have been ^{14}C -dated, of which four of the upper fine-grained sediments (36.50 - 33.30 m). Only one, 35.70 - 35.50 m, gave an approximate age of > 35 000 B.P. The other three samples gave no exchange on account of the content of organogenous material being too low (or may be too old). Of the lower fine-grained sediments (87.55 - 68.62 m) 6 core samples and 3 mixed samples have been dated. None of the mixed samples gave any exchange. Of the core samples 3 gave no exchange and 3 gave finite ages between 31 380 and 36 995 B.P. with uncertainty up to ± 5880 years.

The results are shown in Fig 42.

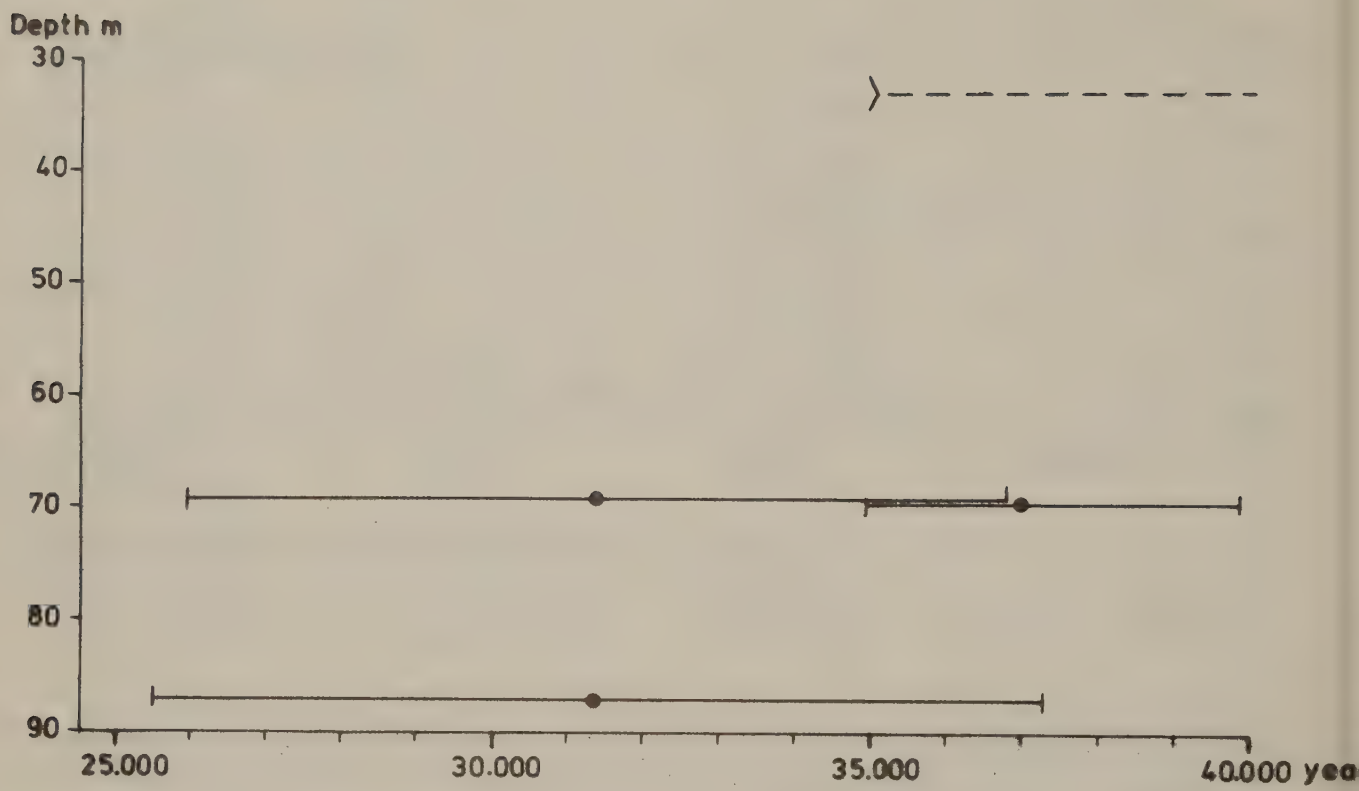


Fig 42. Hyby - core. The ages of the radiocarbon datings of the fine-grained sediments below 68.5 m and between 36.5 and 33.3 m.

The ^{14}C -ages obtained from the fine-grained sediments of the Hyby core seem to be extremely uncertain. It would be too unwise to accept them as the approximate age of sediment formation without any confirmation from biostratigraphical results. Presuming that the fine-grained sediments in Hyby core are of the same age as the ^{14}C -datings, then the interglacial pollen flora and the Pleistocene lacustrine diatom and green-algae floras present in these sediments must be redeposited during the Middle-Weichselian interstadial. The overlying strata must be formed by redeposition of older tills with high content of Eocene diatoms and the interglacial pollen spectra in the fine-grained sediments 48.5 - 31.5 m must be a result of redeposition of interglacial sediments under glacial conditions. These interpretations seem to contain too many circumstantial coincidents of concocted redeposition to be acceptable.

The alternative and probably more reliable interpretation would be that the uncertain ages are a result of contamination by recent organogenous material in connection with core-drilling. The Hyby-core was drilled in summer, while the Gärdslov-core was drilled in winter. It is possible that the length of time the core material was exposed to high-summer air at the boring-site in connection with preliminary lithostratigraphical examination and packing in wooden chests, was enough to cause the contamination. It should be remembered that the main part of the samples from the fine-grained sediments of the Hyby-core have not finite ages. The result "no exchange" may in some cases depend also on too old an age of the material. The samples between 81.45 and 74.65 m represent the sediments with high content of extant pollen, spores, green-algae and diatoms. None of them gave a finite age.

^{14}C -ages between 30 000 and 45 000 B.P. have been the problematical ones (Olsson 1968) also in connection with other stratigraphical investigations of Pleistocene material as Karuküla in southern Estonia (Serebryanny & Raukas Liivrand 1972) which now is accepted as Holsteinian (Likhvin) deposit and the redeposited Eemian clay in Somero, Finland deposit (Donner & Garde-meister 1971, Donner & Jungner 1973, 1974).

3.4. Proposal to stratigraphical division of the Pleistocene deposits of the Alnarp Valley, taking into account the present knowledge of its litho-, bio- and chronostratigraphy - A tentative stratigraphical interpretation

The litho-, bio- and chronostratigraphical results discussed above are compiled into a tentative stratigraphical scheme presented as Fig 43.

The lacustrine sediments of the Hyby-core below 68.5 m, which indicate interglacial conditions, are called HYBY I.

The redeposited interglacial sediments of the Hyby core between 48.5 and 31.5 m, are called HYBY II.

The fluvial sediments of the Gärdslov-core below 80 m are called GÄRDSLÖV I and the uppermost sediments of the Gärdslov core 6.4 - 2 m are called GÄRDSLÖV II.

The stratigraphical positions of these sediments are shown in Fig 43 and the alternative interpretations are presented below:

Litho-/biostratigraphyChronostratigraphy

sediments, GÅRDSLÖV II

Late Weichselian

Younger Baltic tills

North-Eastern tills

Baltic till

Late Middle Weichselian

sediments GÅRDSLÖV I

sediments HYBY II

Middle Weichselian

(incl. redeposition of Eemian and pre-Eemian)

Old Baltic till

Alt. 1

Saalian, s.l.

Alt. 2

Saalian, Warthe-stadial

sediments HYBY I

Holsteinian

Saalian, interstadial (warm)

Old Northern till

Elsterian

Saalian, Drenthe-stadial

sediments

pre- or inter-
Elsterian

pre-Drenthe

bedrock

Danian (Lower Paleocene)

Fig 43. Tentative stratigraphical interpretation of the Pleistocene deposits of the Alnarp Valley, taking into account the present knowledge of the litho-, bio- and chronostratigraphy

Lithostrati- graphy	Micro- fossil units	Stratigraphical interpretation	Chronostratigraphy			se- ries	
			Stage	Substage	approx. ¹⁴ C-age B.P.		
Sand, or lacking		post-glacial	(FLANDRIAN)	Early Flandrian	9.500	HOLO- CENE	
Sediments, fine-grained	11	GÅRDSLÖV II interstadial	W	Late Weich- selian	11.500	P	
Sediments	10	YOUNG	E	Late Middle Weichselian		L	
Till	9	LOW } BAL TIC	I			E	
Till + sediments	8	Middle } ice	C			I	
Till	7 ^V	NORTHERN	H			S	
Sediments, mixed with till or stratified	7 ^{IV}	N } ice	S			T	
	7 ^{III}	NE }	E	Middle Weichselian	21.500 23.000 27.500	O	
Till	7 ^{II}	BALTIC ice	L			C	
Sediments	7 ^I		I			E	
			A	(Early Weichselian)		N	
Sediments, fine-grained,	6	GÅRDSLÖV I interstadial	N			Middle Weichselian	E
mainly fluvial (Grävie-sand)	5	HYBY II redeposited					
and clay	4 ^{II}	interglacial	(EEMIAN)			E	
Till	4 ^I	OLD BALTIC	SAALIAN	cf p. 104	no exchange and dis- carded ¹⁴ C-datings cf p. 102		
Sediments, coarse	3 ^{II}	ice					
Sediments, fine- grained, main- ly lacustrine	3 ^I	HYBY I interglacial	HOLSTEINIAN or (pre-EEMIAN)				
Till	2	OLD NORTHERN	ELSTERIAN or				
Sediments	1/2	ice	OLDER SAALIAN				
Bedrock (limestone)	1	DANIAN	LOWER PALEOCENE			PA- LEO- CENE	

SUMMARY

Material from three core-borings in the Alnarp Valley, southern Sweden (the Tofthög-, Hyby- and Gärdslov-cores) has been studied with regard to its content of microfossils. Different types of microfossil analysis have been applied to evaluate:

- 1) the lithostratigraphical use of reworked microfossils (palynomorphs and siliceous microfossils) as a complement to fine gravel analysis and to register variations in the lithological composition of different tills and sediments
- 2) the biostratigraphical importance of Pleistocene pollen and diatom spectra in the minerogenous fine-grained sediments (submorainic, intermorainic and supramorainic)
- 3) the chronostratigraphical use of the radiocarbon datings made on these sediments.

Five different types of till have been distinguished according to their microfossil content spectra. The three upper till beds are proposed as being deposited during the last glaciation (Late Middle Weichselian tills). The two lower till beds are assumed to be deposited during older glaciations (Saalian and Elsterian tills or two different Saalian tills). The Pleistocene pollen and diatom spectra in the fine grained sediments register:

- 1) an interglacial or warm interstadial stage of Holsteinian or Middle to Late Middle Saalian age (HYBY I),
- 2) redeposition of Eemian and/or pre-Eemian sediments during a cold-temperate interstadial substage probably of Middle Weichselian age (HYBY II and GÄRDSLÖV I)
- 3) Late Weichselian sedimentation during Older Dryas, Alleröd and Younger Dryas (GÄRDSLÖV II).

The radiocarbon datings of the GÄRDSLÖV II sediments support the Late Weichselian age (11 500 B.P.). Certain of the radiocarbon ages of GÄRDSLÖV I may be presumed reliable (21 500 - 27 500 B.P.), while the datings of HYBY I and HYBY II sediments are discarded, on account of their varying and uncertain ages probably caused by contamination.

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HYBY CORE: SILICEOUS MICROFOSSILS. LIST of SPECIES

LITHOLOGY	STRATUM.	DANIAN BED- ROCK	SEDIMENTS (FINE GRAINED)				SEDIM. (COARSE)	TILL				SEDIM.	TILL + SEDIM.	TILL
	DEPTH M	← 95.50	95.5 — 69.1				69.1 — 59.2	59.2 — 39.0				39.0 — 32.0	32.0 — 21.7	21.7 — 4.0
	MAIN COMPONENT	LIMESTONE + GRAVEL + SAND	SILT + SAND	SILT + SAND	SILT + SAND	STONE + CLAY	SOILS CLAY + SAND	SOILS CLAY + SAND	SOILS CLAY + SAND	SOILS CLAY + SAND	SOILS CLAY + SAND	SOILS CLAY + SAND	SOILS CLAY + SAND	
STRATI- GRAPHY	STRATIGRAPHICAL UNIT SPECTRA M	95.0 95.0	95.0 95.0	89.25 82.0 87.0 81.6	81.6 — 71.6 69.1	69.1 59.2	59.2 55.0 52.4 48.6 42.0 55.0 52.4 48.6 42.0 39.0	39.0 33.4 32.0 30.0 25.1 33.4 32.0 30.0 25.1 21.7	32.0 — 21.7	21.7 18.0 12.0 18.0 12.0 4.0				
	No OF SAMPLES ANALYSED / SPECTRA	9	19	10 6 9	4 5	9	4 4 6 2	5	1 3 3 1	2 1 3				
	DIATOM HYBY UNITS (TOFTHÖG)	1(+3)		3 a		3 b		4 a 4 b 5	6	7 a 7 b	8			
DIATOMS: PLEISTOCENE														
CENTRALES:														
<i>Chaglaceros Ebg</i>														
<i>holseticus</i> Schütt (resting spores)														
<i>Cyclotella Ebg</i>														
<i>compta</i> (Ebg) Kz.														
<i>v. radiosa</i> Gr.														
<i>Myoladiscus Ebg</i> cf. <i>scoticus</i> (Kz.) Gr.														
<i>Melosira Ag.</i>														
<i>arenaria</i> Moore														
<i>f. scabra</i> Östrup														
<i>distans</i> (Ebg) Kz.														
<i>islandica</i> O. Müller														
<i>sulcata</i> (Ebg) Kz.														
<i>Stephanodiscus Ebg</i>														
<i>astraea</i> (Ebg) Gr.														
<i>v. minutula</i> (Kz.) Gr.														
I CENTRALES														
PENNALES:														
<i>Camptodiscus Ebg</i>														
<i>clypeus</i> Ebg														
<i>hibernicus</i> Ebg														
<i>Cocconeis Ebg</i>														
<i>diminuta</i> Pantocsek														
<i>placentalis</i> Ebg														
<i>v. intermedia</i> (Hér. et Per.) Hust.														
<i>Cymbella Ag.</i>														
<i>aspera</i> (Ebg) Cl.														
<i>cistula</i> Hemprich														
<i>cuspidata</i> Kz. v. <i>anglica</i> (Lgst.) A. Cl.														
<i>hebridica</i> (Grog.) Cl.														
<i>naviculiformis</i> Auerswald														
<i>prostrata</i> (Berk.) Cl.														
<i>sinuata</i> Grog.														
<i>ventricosa</i> Kz.														
<i>Diploneis Ebg</i>														
<i>sp. aff. smithi</i> (Bréb.) Cl.														
<i>sp.</i>														
<i>Epithemia Bréb.</i>														
<i>argus</i> Kz.														
<i>zebra</i> (Ebg) Kz.														
<i>v. saxenica</i> (Kz.) Gr.														
<i>sp.</i>														
<i>Eunetia Ebg</i>														
<i>clevei</i> Gr.														
<i>diodon</i> Ebg														
<i>flexuosa</i> (Bréb.) Cl.														
<i>grunewi</i> A. Berg														
<i>v. splendens</i> A. Cl.														
<i>lapponea</i> A. Cl.														
<i>parallela</i> Ebg														
<i>sudetica</i> (O. Müller) Hust.														
<i>valida</i> Hust.														
<i>veneris</i> (Kz.) O. Müller														
<i>spp.</i>														
<i>Fragilaria Lyngbye</i>														
<i>construens</i> (Ebg) Gr.														
<i>v. binodis</i> (Ebg) Gr.														
<i>Frustulia Ag.</i>														
<i>rhomboides</i> (Ebg) de Toni														
<i>v. saxenica</i> (Rbh.) de Toni														
<i>Gomphonema Ag.</i>														
<i>constrictum</i> Ebg														
<i>gracile</i> Ebg														
<i>lanceolatum</i> Ebg														
<i>Hantzschia Gr.</i>														
<i>omphioxys</i> (Ebg) Gr.														
<i>Meatoglaia Thwaites</i>														
<i>baltica</i> Gr.														
<i>Navicula Bory</i>														
<i>jantzschi</i> Gr.														
<i>Naidium Pfitzer</i>														
<i>hercynicum</i> Mayer														
<i>Nitzschia Hassal</i>														
<i>obtusa</i> W. Sm.														
<i>Opephora Petit</i>														
<i>martyi</i> Hér. et Per.														
<i>Pinnularia Ebg</i>														
<i>cl. angustofasciata</i> A. Cl.														
<i>gibba</i> Ebg														
<i>v. linearis</i> Hust.														
<i>late</i> (Bréb.) W. Sm.														
<i>microstaurum</i> (Ebg) Cl.														
<i>subcapitata</i> Grog.														
<i>sudetica</i> Milne														
<i>spp.</i>														
<i>Rhabdonema Kz.</i>														
<i>arcuatum</i> (Lyngbye? Ag.) Kz.														
<i>minutum</i> Kz.														
<i>v. sulcatum</i> Pricke														
<i>Rhabdonema O. Müller</i>														
<i>gibba</i> (Ebg) O. Müller														
<i>parallela</i> (Gr.) O. Müller														
<i>Stauroneis Ebg</i>														
<i>phoenicenteron</i> Ebg s.l.														
<i>Sarirella Tyrain</i>														
<i>sp.</i>														
<i>Synedra Ebg</i>														
<i>ulna</i> (Nitzsch) Ebg														
<i>Tabellaria Ebg</i>														
<i>fenestrata</i> (Lyngbye) Kz.														
<i>flaccuosa</i> (Roth) Kz.														
Varia: PENNALES (fragm.)														
I PENNALES														
I PLEISTOCENE DIATOMS														

STRATI- GRAPHY	STRATIGRAPHICAL UNIT SPECTRA M		96.0	95.0	89.25	87.0	81.6	71.6	69.1	59.2	55.0	52.4	48.6	42.0	39.0	33.4	32.8	30.0	25.1	21.7	18.0	12.0
	DIATOM HYBY UNITS (TOFTHÖG)		95.0	89.75	87.0	81.6	71.6	69.1	59.2	55.0	52.4	48.6	42.0	39.0	33.4	32.8	30.0	25.1	21.7	18.0	12.0	4.0
			1(+3)	3a			3b		4a	4b	5	6	7a	7b	8							
		I		III			IV		V		VI	VII		VIII								
SILICOFLAGELLATES :																						
Dictyocha Ebg																						
fibula Ebg																						
v. aspera Lemmermann																						
navicula Ebg																						
v. biapiculata Lemmermann																						
staurodon Ebg																						
spp (fragm. Dictyocha - Mesocena)																						
Distephanus Haeckel																						
speculum (Ebg) Haeckel																						
v. pentagonus Lemmermann																						
Ebria Borgert																						
antiqua Schulz s.l.																						
v. antiqua Schulz																						
v. rectangularis Schulz																						
v. simplex Schulz																						
sp. (fragm.)																						
Mesocena Ebg																						
polymorpha Lemmermann																						
Σ SILICOFLAGELLATES																						
SPONGES :																						
Varia SPICULES fragm.																						
PYCNASTER																						
Spongilla gigantea (PYCNASTER)																						
Σ SPONGES																						
Σ SILICEOUS MICROFOSSILS (BASIC SUM 100%)		161	6	21	3	20	33	6	2148	528	83	1503	141	84	388	256	132	133	64	75	74	
		167		44		39			2676	83	1644	84	644		265							
OTHER MICROFOSSILS :																						
RADIOLARIA																						
Σ D (No and %) per DIATOM UNIT :		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
DIATOMS :		166	100	44	100	39	100	2676	100	100	1644	100	100	643	100	265	100	213	100			
PLEISTOCENE																						
CENTRALES		7	4	3	7	—	—	3	+	—	3	+	—	—	—	—	—	—	—	—	—	
PENNALES		63	38	11	25	3	8	181	7	—	3	+	—	1	+	—	—	—	1	0.5		
LOWER TERTIARY-UPPER CRETACEOUS																						
IDENTIFIED		2	1	7	16	11	28	688	26	15	522	32	7	175	27	42	16	29	13.5			
FRAGMENTS UNIDENTIFIED		2	1	6	13	4	10	1037	38	24	559	34	8	224	35	41	15.5	30	14			
VARIA TRANSFORMED																						
(DIATOMS AND SILICOFLAGELLATES)		93	56	7	16	1	3	85	3	12	46	3	37	12	2	1	0.5	25	12			
SILICOFLAGELLATES :																						
SPONGES, SPICULES :																						

Table 4. HYBY core samples 55.05 m and 58.0 - 59.2 m (clay and/or boulder clay - silt)

Pleistocene diatoms: epiphytic and benthic fresh-water forms

55.05 m sample

70% acidophilous (e.g. Eunotia spp., Frustulia spp., Pinnularia spp., Tabellaria flocculosa)

15% indifferent to pH (e.g. Gomphonema constrictum, Tabellaria fenestrata-type)

15% alkaliphilous (e.g. Cymbella navi-culiformis, Cymb. ven-tricosa, Gomphonema gracile, Synedra ulna)

58.0 - 59.2 m samples

88% acidophilous (e.g. Cymbella hebridica, Eunotia, Frustulia and Pinnularia spp.)

12% indifferent to pH and alkali-philous (e.g. Fragilaria spp., Hantzschia amphioxys, Stauro-neis phoenicenteron)

Table 5. HYBY core-samples

55.05 m and 58.0 - 59.2 m

(clay and/or boulder clay + silt)

Siliceous microfossils: marine
Lower Tertiary (Eocene and Danian)
Diatoms: centric (Eocene/or older)

Arachnoidiscus indicus v. borealis
Aulacodiscus sp.
Coscinodiscus heteroporus
Craspedodiscus oblongus
Endictya oceanica
Hemiaulus dano-suecicus
februatus
proteus-danicus
pungens
Lepidodiscus sp.
Meiosira clavigera
ornata
sulcata v. biseriata, v. crenulata
v. sibirica
Pyxilla gracilis
Stephanopyxis broschii
ferox
marginata
megapora
möllerii
turris v. arctica
Triceratium spp.
Trinacria spp.

Silicoflagellates (Eocene and Danian)
Transformed frustules (Danian)
Sponge spicules (Eocene and Danian)

Table 6. HYBY core-samples

95.50 - 96.19 m

(sand and gravel, crack-filling in limestone)

Pleistocene diatoms: fresh-water forms

70% epiphytic forms:

Cymbella aspera (alk)
cistula (i)
cuspidata (alk)
naviculiformis (i)
sinuata (alk)
Cocconeis placentula (alk)
Epithemia zebra (alk)
Eunotia diodon (ac)
grunowi (ac)
Gomphonema constrictum (alk)
gracile (alk)
lanceolatum (alk)
Opephora martyi (alk)
Tabellaria fenestrata (i)

17% benthic forms:

Pinnularia gibba (ac)
spp. (fragments) (ac)
Stauro-neis phoenicenteron (i)
spp. (i)

13% planktic forms:

Cyclotella comta v. radiosa (i/alk)
Melosira arenaria (alk)
arenaria/scabrosa-type (alk)

60% alkaliphilous (alk) 12 taxa
25% indifferent to pH (i) 5 taxa
15% acidophilous (ac) 4 taxa

Σ 21 taxa

GARDULOV CORE : SILICEOUS MICROFOSSILS. LIST of SPECIES

ARABUS CORE : SILICEOUS MICROFOSSILS. LIST OF SPECIES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
LITHOLOGY	STRATUM	CRET.	SEDIMENTS				TILL		SEDIMENTS		SEDIMENTS				SEDIMENTS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	DEPTH M	BEDROCK	106.5-77.0				77.0-60.9		45.0-5.7		5.7-0				5.7-0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
MAIN COMPONENT	SAND	SILT	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY	CLAY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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STRATI- GRAPHY	STRATIGRAPHICAL UNIT SPECTRA		M										5.7 5.0										5.0 3.9										3.9 3.5										3.5																
	ZONES	GÄRDSLÖV ALNARP	A										B:1	B:2										B:3	C	D	E										F																						
			106.75-77.0											70.0-51.5													51.5-40.0											40.0-12.5										12.5-5.7										5.7-3.5	
DIATOMS: LOWER TERTIARY (UPPER CRETACEOUS)																																																											
<i>Arachnoidiscus</i> Bailey																																																											
cf. <i>indicus</i> Ebg v. <i>borealis</i> A.Cl.																																																											
off. <i>Biddulphia</i> Gray																																																											
off. <i>Brightwellia</i>																																																											
<i>Chaetoceros</i> Ebg																																																											
sp. (fragm.) cf. <i>Ch. lorenzianus</i> Gr.																																																											
<i>Coscinodiscus</i> Ebg																																																											
heteroporus Ebg—decrescens Gr. (fragm.)																																																											
cf. <i>Radiati</i> sp. (fragm.)																																																											
spp.																																																											
<i>Craspedodiscus</i> Ebg																																																											
moelleri A.Sm. (fragm.)																																																											
<i>Endictya</i> Ebg																																																											
zabellinae A.Cl.																																																											
<i>Hemiaulus</i> Ebg																																																											
spp. (fragm.) <i>Hemiaulus</i> — <i>Triceratium</i> ?																																																											
<i>Hesslandia</i> A.Cl.																																																											
cf. <i>scanica</i> A.Cl. (umbilicus)																																																											
<i>Hyalodiscus</i> Ebg																																																											
<i>laevis</i> Ebg																																																											
off. <i>radiatus</i> (O.Müller) Gr.																																																											
v. <i>arcticus</i> Gr.																																																											
spp. (umbilicus)																																																											
<i>Lepidodiscus</i> A.Cl.																																																											
sp. (umbilicus)																																																											
<i>Melosira</i> Ag. (<i>Paralia</i> Heiberg)																																																											
ornata Gr.																																																											
<i>sulcata</i> (Ebg) Kz. (fragm.) s.l.																																																											
v. <i>biseriata</i> Gr.																																																											
f. <i>major</i> A.Cl.																																																											
f. <i>minor</i> A.Cl.																																																											
v. <i>grenulata</i> Gr. f. <i>radiata</i> et radiolata Gr.																																																											
v. <i>siberica</i> Gr. f. <i>radiata</i> Gr.																																																											
off. <i>Pyrgodiscus</i> O.Witt.																																																											
<i>Pyxidicula</i> Ebg																																																											
off. <i>minuta</i> Gr. (<i>P. melosiroides</i> A.Cl.)																																																											
<i>Pyxilla</i> Grev.																																																											
<i>gracilis</i> Tempère & Forti																																																											
spp. (fragm.)																																																											
<i>Sceptroneis</i> Ebg																																																											
<i>gemmata</i> Gr.																																																											
<i>Stephagonia</i> (Ebg) V. Heurck																																																											
<i>polygona</i> Ebg																																																											
<i>Stephanopyxis</i> Ebg																																																											
<i>marginata</i> Gr.																																																											
<i>turris</i> (Grev. & Arn.) Rolfs (fragm.)																																																											
v. <i>arctica</i> Gr.																																																											
v. <i>subglobosa</i> A.Cl.																																																											
spp.																																																											
<i>Triceratium</i> Ebg																																																											
<i>abyssorum</i> Gr.																																																											
spp. (fragm.) <i>Triceratium</i> — <i>Trinacria</i> ?																																																											
<i>Trinacria</i> Heiberg																																																											
cf. <i>pileatus</i> (Ebg) Gr.																																																											
Σ TERTIARY/CRETACEOUS DIATOMS, identified																																																											
Σ TERTIARY/CRETACEOUS DIATOMS, small fragm. (areols)																																																											
Σ VARIA TRANSFORMED (CRETACEOUS) (DIATOMS/SILICOFLAGELLATES)																																																											
SILICOFLAGELLATES:																																																											
<i>Dictyocha</i> Ebg																																																											
<i>navicula</i> Ebg v. <i>biapiculata</i> Lemmermann																																																											
<i>stauredon</i> Ebg																																																											
<i>Dictyocha</i> — <i>Distephanus</i> Haeckel																																																											
fragm.																																																											
<i>Dictyocha</i> — <i>Mesocena</i> Ebg																																																											
fragm.																																																											
<i>Ebria</i> Borgert																																																											
<i>antiqua</i> Schulz s.l. (fragm.)																																																											
v. <i>antiqua</i>																																																											
v. <i>simplex</i> Schulz																																																											
Varia: SILICOFLAGELLATES (fragm.)																																																											
Σ SILICOFLAGELLATES:																																																											
SPONGES:																																																											
<i>Vonia spicules</i> fragm.																																																											
<i>Spongia gigantea</i> (pyncaster)																																																											
Σ SPONGES:																																																											
Σ SILICEOUS MICROFOSSILS (BASIC SUM 100%)																																																											
OTHER MICROFOSSILS:																																																											
RADIOLARIA																																																											
FORAMINIFERA																																																											
VARIA CYSTS																																																											
PERCENTAGES (%) AVERAGE/STRATUM																																																											
DIATOMS:																																																											
PLEISTOCENE																																																											
PENNALES																																																											
CENTRALES																																																											
LOWER TERTIARY—UPPER CRETACEOUS																																																											
IDENTIFIED																																																											
FRAGMENTS UNIDENTIFIED																																																											
VARIA TRANSFORMED (DIATOMS SILICOFLAGELLATES)																																																											
SILICOFLAGELLATES:																																																											
SPONGES, SPICULES:																																																											

